1. BACKGROUND

1.1. The possibility of a rail link between Central London and Heathrow Airport was considered as long ago as 1956. The conclusion then was that there was not enough traffic to justify the capital expenditure needed.

1.2. The road improvements carried out during the late 1950's and early 1960's, culminating in the opening of the M4 all the way to the Airport, meant that the airline coaches could continue to operate with a reasonable degree of speed, time keeping and reliability although with occasional serious delays. By the beginning of 1966 it again appeared that a rail link would be able to offer airline passengers considerable time savings and that traffic might be enough to make such a link a viable financial proposition too.

1.3. The Interchanges Group of the Transport Co-ordinating Council for London (TCCL) studied several possible rail links and concluded that two proposals were likely to provide satisfactory solutions:—

i. a British Railways link from Victoria,

ii. an extension of London Transport's Piccadilly Line to the Airport.

1.4. Parliamentary powers were obtained for both, and a detailed study was launched. TCCL felt that non-conventional rail links should also be given an opportunity to prove their worth and three detailed proposals were put forward for consideration. In the event all were ruled out, partly because they were not sufficiently developed. But the main reason why unconventional rail links cannot compete seriously with the two conventional systems of linking Central London and Heathrow is that they would have to be started from scratch, whereas both British Railways and London Transport have existing track over much of the route.

1.5. In July 1967 the TCCL Study Group reported, recommending that a British Rail link from Victoria should be built. That scheme included new terminal facilities at Victoria, and was essentially the same as Scheme BR 1 in the present study. The London Transport representative on that Group entered a statement of dissent, maintaining that LT's less expensive proposal would meet the need.

1.6. Responsibility for the development of the Victoria and Heathrow ends of the link was placed with a consortium comprising BRB, BAA, BOAC, and BEA while BR retained sole responsibility for all works relating to railway operations. The BR link could only be viable in financial terms if the major airlines ceased to run their airport coaches. As discussion progressed it became evident that the airlines were reluctant to do this because:—

i. they could not be sure that their competitors would do likewise;

ii. the airlines believed that the world-wide trend was away from large scale in-town check-in points towards air passengers making their own way to the airport and checking in there. It therefore seemed wrong to contemplate providing major new facilities in Central London.

iii. at a later stage the consortium Steering Group ran into considerable problems in devising a suitable system for handling baggage between Victoria and Heathrow.

1.7. Meanwhile London Transport were still pressing their scheme for an extension of the Piccadilly Line. So in Autumn 1969 the President of the Board of Trade and the Minister of Transport called together representatives of all the interested parties and proposed a detailed cost-benefit analysis of the BR and LT proposals, and the Heathrow Link Steering Group was formed to carry out that task. The first volume of their report, "Part I: Summary and Conclusions" was published in May 1970. This second volume gives more details of the study, though without being a complete record of all the work that was done.

2. THE SCOPE OF THE STUDY

2.1 *The Schemes Considered*

2.1.1. We did not consider it acceptable to do away entirely with check-in at a London centre. We decided therefore that the Piccadilly Line service would not be satisfactory as the sole public transport link with the Airport and that it must be considered as complementary to the coach services. Since the Airlines were doubtful about withdrawing their coaches we decided to consider the BR link both with and without continued coach services. Later, during the course of the study, we decided that we should also consider a fourth possibility; a BR link without new terminal facilities at Victoria but with continued coach services. So the four schemes we examined were:—

Scheme	Service
BR 1	An exclusive British Rail link between Victoria and Heathrow, with check-in at Victoria and with coach services withdrawn
BR 2	A similar link to BR 1 but with coach services continuing
BR 3	A similar link to BR 1 but without check-in at Victoria and with coach services continuing
LT	Extension of the Piccadilly Line to Heathrow, with coach services continuing

In each case the options of private transport, taxis and charter coaches, all with check-in at the Airport, would remain.

2.1.2. We then attempted to ensure that all the systems were feasible; to analyse their relative merits in terms of costs and benefits (both quantified and unquantified) and to assess their financial prospects.

2.2. *Feasibility*

2.2.1. The basis for the estimates of total air passenger traffic at Heathrow on specific dates in the future is described in section 4.2. As there was no evidence that the means available for travel to the airport would affect the

number of air passengers, we used these estimates throughout the study. But the relative numbers carried by the various public links will differ, since some will obviously attract more passengers than others. The basis and justification of the particular loadings we have used is described in section 4.3. Each system provides enough capacity to handle not only our highest estimate of airline passengers but also the spectators, friends, miscellaneous passengers and airport workers we expect to use it.

2.3. *The Cost-Benefit Analysis*

2.3.1. The cost-benefit framework compares all four schemes on an equivalent basis. We have included both the direct costs and benefits of building and operating the link and the external costs and benefits, mainly in road congestion. Table 5.1 gives a detailed list of the individual items we have included.

2.3.2. In assessing the social costs and benefits of the various proposals the present "coaches only" system has been taken as a datum point. This would itself involve expenditure, on new coaches and on running them, to provide adequate capacity for future growth in air traffic. Since the potential volume of Heathrow airline traffic is not being questioned, this minimum expenditure is taken as inevitable. We have not assumed any major new roadworks on the M4 or on the approaches to it.

2.3.3. Three main categories of cost have been considered:—

i. User costs; which include the time, vehicle operating costs and fares of users of the public transport link. When compared with maintaining the "coaches only" situation savings in user costs can be regarded as benefits. As table 5.1 shows clearly, user cost savings are easily the most important of the benefits for all the rail links we considered. We have included all users of the link; airport workers as well as air passengers.

ii. Indirect costs; mainly in road congestion affecting other road users, resulting from different use of the roads under each scheme. All four schemes would reduce the total amount of road mileage travelled by airport users. Any worsening in travelling conditions experienced by non-airport commuters on the LT system due to increased numbers of air passengers on the trains would also be an indirect cost of that scheme although we have not attempted to measure those costs in money terms.

iii. Direct costs; which cover capital and operating costs for terminals, roadworks, check-in and parking at the in-town end; and link costs including rolling stock and coaches. At the Airport the central terminal, distribution system, check-in, parking facilities and roadworks are all included.

2.3.4. For the purposes of this study benefits are defined as the total of savings in operating costs, time savings by users and reduced road congestion costs. The costs of each scheme have been taken as those additional to the cost of maintaining a coach link capable of dealing with the expected growth in air

travel. The values of both costs and benefits arising over the 25 year period from 1970 to 1994 have been discounted to 1970 at 10%. Details of the method are in Chapter 4, and the results in Chapter 5.

2.4. *The Financial Assessment*

2.4.1. We have also assessed the financial prospects of each of the four schemes, using the same traffic and cost estimates as in the cost-benefit analysis. The results are described in Chapter 5.

2.5. *The Factors which have not been included in the Calculations*

2.5.1. There are a number of significant factors which cannot be costed in money terms but which must also be taken into account:—

i. the advantages of choice in schemes which offer both rail and coach travel
ii. the choice of being able to check-in in Central London or of saving time by checking-in at the Airport
iii. comfort
iv. baggage handling facilities
v. reliability
vi. town planning considerations

Our assessment of these factors is in Chapter 7, and is summarised in Table 7.1.

3. DESCRIPTION OF THE SCHEMES

3.1. *Coaches only*

3.1.1. All four schemes have been compared with a projection of the present system of town terminals and coach operations to the level which would be necessary to meet future loads. As compared to the TCCL report we have not included the cost of roadworks to improve coach journey times. Instead, we have forecast the reduction in coach speeds which will result from the growth of traffic congestion on the route to the Airport.

3.1.2. This is a major difference from the TCCL study in which road costs of several million pounds were charged against the "coaches only" and "London Transport plus coach" schemes. These road costs were based on improvements along the coach route which that Group thought would be necessary to maintain a service with a 35 minute journey time from West London. The possibility that these improvements would in fact have been made was at best hypothetical. Our study is based on an estimate of the deterioration in coach journey times and the benefits of the other schemes are calculated against that "do nothing" situation. The net effect is to increase both the additional costs and benefits of all the four schemes as against retaining the coaches as the only public transport link. It also brings the LT scheme onto a more truly comparable basis with the BR options.

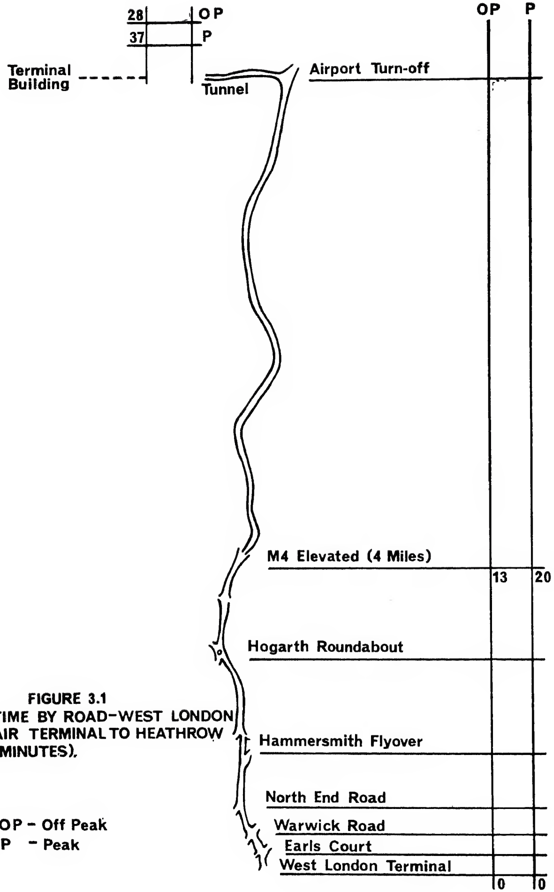


FIGURE 3.1
TIME BY ROAD–WEST LONDON AIR TERMINAL TO HEATHROW (MINUTES).

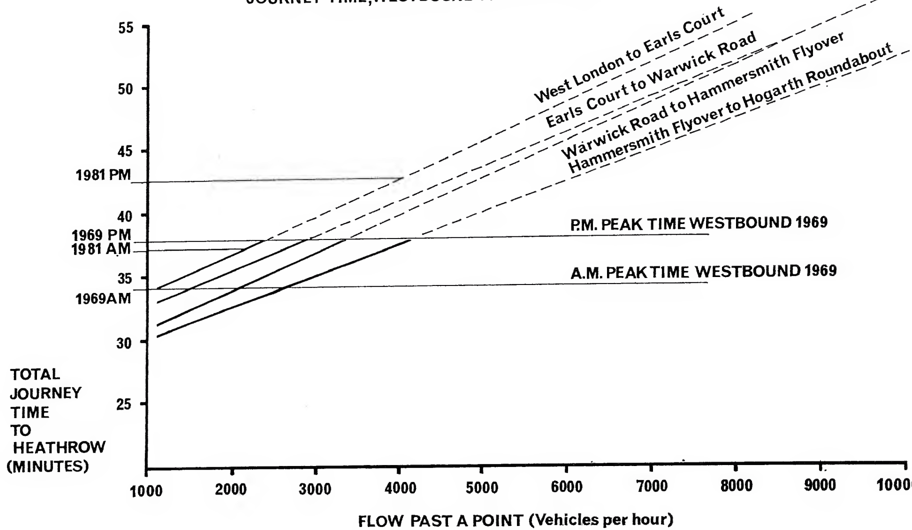
OP – Off Peak
P – Peak

TABLE 3.1

Journey times and traffic flows, West London to Heathrow

		TIME	FLOW PAST 4 POINTS (Vehicles per hour)			
		Average time to Heathrow (minutes)	Terminal to Earls Court	Earls Court to Warwick Road	Warwick Road to Hammersmith Flyover	Hammersmith Flyover to Hogarth Roundabout
A.M.	1969	34	1,235	1,444	2,099	2,577
P.M.	1969	37	2,298	2,852	3,394	4,091
A.M.	1981	37	2,210	—	—	—
P.M.	1981	42	4,100	—	—	—

FIGURE 3.2 FLOW PAST 4 SELECTED POINTS VERSUS TOTAL HEATHROW JOURNEY TIME, WESTBOUND A.M. AND P.M.



3.1.3. Figure 3.1 shows a map of the route from West London to Heathrow with some typical times for westbound journeys in peak and off-peak periods. The difference between the peak and off-peak journey times is very largely accounted for on the in-town section of the route. Recent studies on the M4 by the Road Research Laboratory indicate that there is no significant speed reduction over a very wide range of traffic flows or indeed within any upper limit so far observed.

3.1.4. Table 3.1 lists weighted average times for a sample of 2098 westbound coach journeys, taken from BEA records for 1968 and 1969. The average times for morning and evening peak journeys for this period are shown against measured traffic flows at 4 points on the route. These flows were plotted against the journey times to give the four time/flow lines shown on Figure 3.2. The lines are shown dashed for flows greater than the observed upper limit to indicate that extrapolation beyond this range is hypothetical.

3.1.5. Taking the steepest line as the worst case for estimating future times, the morning and afternoon flows were increased at 5% a year to give the 1981 estimated flows shown in Table 3.1. These flows were then plotted on Figure 3.2, to give estimated journey times in 1981. The morning peak flow for 1981 on this basis was still less than the observed evening peak flow in 1969. Because this falls within the plotted range, the 1981 estimated morning peak time of 37 minutes should be a reasonably likely figure. The afternoon peak flow falls in the unobserved portion of the curve. On a straight-line basis, the journey time would be about 43 minutes. To allow for the possibility that the curve may be non-linear, we have added an arbitrary 7 minutes. This gives the estimated peak time of 50 minutes used in the study. The off-peak time of 40 minutes includes a similar margin. As most of this extra time would be lost on the in-town portion of the trip these figures imply a considerable reduction in speeds on this part of the journey.

3.1.6. Table 3.2 shows a breakdown of the 2098 trips according to time groups. From this it appears that the reliability of the coach times from West London to the Airport has been very good within the observed range. Similar reliability would therefore be expected during the 1981 morning peak and off-peak times. And a considerable proportion of the over 41 minute trips can be accounted for by special circumstances, like breakdowns or extensive roadworks, or by extreme weather conditions.

3.1.7. These forecasts apply only to westbound trips from West London. Detailed logs of journey times are kept for these trips because of the importance of reliability on departures. No equivalent records are kept of eastbound trips, which are thought to take about 5 minutes longer, because there are more involved turning movements caused by the traffic system and approaches.

3.1.8. As a further measure of caution, we have used an average journey time of 45 minutes in our calculations. This too is pessimistic because the afternoon peak time of 50 minutes would apply to less than half of the traffic.

TABLE 3.2

Analysis of Coach Trips by Journey Time—
Sample of 30 Days Monday-Friday (1968-1969)

	Off-Peak	Peak	Total	%
Journey less than 35 mins.	725	728	1,453	69·3
36 to 40	118	336	454	21·6
41 to 45	5	82	87	4·1
46 to 50		35	35	1·7
51 to 55		44	44	2·1
56 to 100		25	25	1·2
Total Journeys	848	1,250	2,098	100·0

3.1.9. The evidence available suggests that the coach services would be capable of maintaining a reasonable standard of service, within the limits of the times used in the study, at least until 1981. It is possible that they could do rather better, in which case the time savings of all schemes may be overstated by as much as 5 minutes per trip. If that were true, the net benefit of all schemes would be less, since user time savings for the other four schemes are calculated in relation to these reduced coach speeds. Sensitivity tests have been carried out to test the effects of assuming faster coach journeys (see Chapter 6).

3.1.10. On the other hand, all these calculations relate to coach travel between West London and Heathrow. About 20% of coach traffic is expected to be between Victoria and the Airport. No detailed timings were available on which similar calculations could be based. It may be that journey times would increase more rapidly because of the higher proportion of town mileage.

3.2. *Scheme BR 1—A British Rail link with Victoria, with check-in facilities there but without Coach Services*

3.2.1. This scheme would provide trains exclusively for airport travellers. They would run at a 10 minute frequency during the day and 15 minutes at night and take 23 minutes for the trip. New rolling stock would be provided, and the single fare would be 10s (at 1969 prices). The service would operate from a Victoria terminal complete with check-in and baggage handling facilities. For much of the route the trains would share existing track, which would require some slight modification. Additional track would be required to provide a connection between Victoria and the Waterloo-Windsor lines and for an extension into the Heathrow Central Air Terminal from a point between Feltham and Ashford. Baggage would be handed in at Victoria, and transported on the trains to the Airport by a container system. Although no satisfactory baggage handling system which would meet the requirements of the scheme has yet been designed, the study assumes (on the evidence produced by the group which studied the problem) that such a system is feasible—given adequate time and resources for its development. Passengers arriving at the Heathrow Central Air Terminal would make their way to the departure buildings and join their flights direct. There would be no airline coach services.

3.2.2. The journey time by BR for the trip from Heathrow to Victoria would be faster than comparable journeys either by coach or LT. Overall journey times also are generally shorter by BR for Central and Eastern districts of London. But, because of the effects of the baggage handling system on journey times to the Airport, time savings for departing air passengers would not be so significant.

3.2.3. Congestion caused by private car trips direct to the Airport and to the in-town terminals would be similar to those which would arise anyway in a coaches only scheme. There would in fact be a very slight reduction caused by the withdrawal of the coaches from the route to the Airport and this has been included in the calculations.

3.2.4. The direct costs of operating the coach system would not be incurred, and there might be a small gain from putting the present coach terminals to some other use. Against this there is the cost of providing the Victoria terminal itself, and the check-in and baggage handling systems. Other costs would include the construction of the link, a complete set of rolling stock and a comprehensive airport terminal and distribution system for getting passengers and baggage from the Heathrow railway station to the departure terminals.

3.3. *Scheme BR 2—A British Rail link to Victoria with check-in there, supplemented by continued Coach Services*

3.3.1. Users would have all the advantages of both the BR link and the coach service system.

3.3.2. Direct costs of the coach operation would be reduced because of the slower rate of increase needed in the size of the coach fleet. Total capital and operating costs would be less than the sum of those costs for BR 1 and "coaches only" because of the lower traffic levels on each.

3.4. *Scheme BR 3—British Rail link to Victoria without check-in facilities there but with continued Coach Services*

3.4.1. This scheme would be similar to Scheme BR 2 except that the costs associated with passenger check-in and baggage handling at Victoria and Heathrow would be saved. On the other hand extra costs would be involved at Heathrow similar to those for the LT plus coaches scheme. Checking-in at the Airport reduces overall journey times for departing air passengers (as compared with schemes BR 1 and BR 2) and this would increase the benefits from time savings.

3.5. *Scheme LT—An extension of the Piccadilly Line to the Airport supplemented by continued Coach Services*

3.5.1. This scheme would involve an extension of the Piccadilly Line from Hounslow West to a central Heathrow station, with an intermediate station at Hatton Cross, close to the airport maintenance areas, which would be used chiefly by airport workers. Passengers arriving at the central station would go by subways equipped with passenger conveyors, to the individual flight terminals

and check-in there in the same way as users of private cars and taxis do now. Fares would be at current LT rates plus a surcharge of 6d, eg Heathrow to Hyde Park Corner, a 35 minute journey, would cost 5s. (at 1969 prices). Trains would run every 4 minutes during the peak, every 5 minutes between the peaks from Monday to Friday, and every 7½ minutes during the evenings and at weekends. They would not run at all in the small hours, leaving the coaches as the only public transport link for the 2% or so of air passengers expected to travel at that time. The LT system would be supplemented by the existing coach services which would continue to operate.

3.5.2. Road congestion costs are also compared with the "coaches only" situation. The numbers going directly to the Airport by car would be somewhat less. And because London Transport passengers are assumed to use their nearest LT station, private car mileage to the in-town terminals would be reduced.

3.5.3. The direct costs would be chiefly the rail link itself, involving extra track and rolling stock (plus conversion of existing stock to provide luggage space); additional stations at Hatton Cross and Heathrow Central; a distribution system for getting passengers to the right departure buildings; and increased check-in facilities at Heathrow for passengers who would otherwise have checked in at the in-town terminals. On the other hand there are savings in the slower rate of expansion and replacement of the coach fleet; on in-town coach terminals and check-in facilities; and in reduced coach operating costs.

4. THE COST-BENEFIT STUDY

4.1. *The cost-benefit framework*

4.1.1. All the items included in the cost-benefit analysis are shown in Table 5.1. Direct costs have been calculated in absolute terms. User costs and indirect costs are expressed as differences from the coaches only costs.

4.1.2. The final values of all the benefits and some of the costs listed in the table depend on the forecasts of traffic on each part of the system.

4.2. *Estimated future air passenger traffic*

4.2.1. Growth in passenger traffic at Heathrow depends in the short term on the rate of growth in demand for air travel. At some point in the 1970's the number of aircraft wanting to land at Heathrow during busy periods will exceed runway capacity, and this will cause a slowdown in the rate of growth in passenger traffic. From then on the rate of growth will depend on the extent to which runway capacity can be increased; the rate of growth in average aircraft size; and the extent to which demand builds up in the less busy hours. Table 4.1. gives our low and high estimates. The low estimate is based on a cautious view of these three factors; the high on a less cautious approach. For both we have assumed that traffic ceases to grow after 1981, largely because of the uncertainty which must apply to longer range forecasts. But we recognise that this could be considered a conservative assumption.

TABLE 4.1

Total annual air passengers

Year	LOW ESTIMATE				HIGH ESTIMATE			
	Air Transport Movements (thousands)	Average Passengers per Aircraft	Annual Total Passengers (millions)	Potential Rail Link Passengers (millions)	Air Transport Movements (thousands)	Average Passengers per Aircraft	Annual Total Passengers (millions)	Potential Rail Link Passengers (millions)
1966			10·3				10·3	
1967			—				—	
1968			13·1				13·1	
1969			14·8				15·6	
1970			16·0				17·9	
1971			17·5				20·0	
1972			19·0				22·2	
1973			20·3				24·6	
1974	264	82	21·6	15·8	315	86	27·1	19·8
1975	271	85	23·1	16·9	315	92	28·8	21·0
1976	276	90	24·6	18·0	318	98	31·0	22·6
1977	284	92	26·0	19·0	321	103	33·1	24·2
1978	292	95	27·7	20·2	324	109	35·3	25·8
1979	300	97	29·0	21·2	327	115	37·6	27·5
1980	300	101	30·4	22·2	330	121	40·0	29·2
1981	300	104	31·5	23·0	330	128	42·2	30·8

4.2.2. Of the total airport passengers, some 18% are assumed to be transfer passengers, and a further 9% charter passengers. These have been excluded from the final columns of Table 4.1 which show the number of potential rail link passengers. Some of these have origin or destination zones for which a rail link from Central London would not in fact provide a useful service, but these are identified by the modal split model and excluded at that stage.

4.2.3. The range of total traffic for 1981 adopted for this study is from 31.5 to 42.2 million passengers a year. This compares with a range of from 24 to 37 million, with a most likely figure of 30.5 million, used in the 1967 TCCL Report. The increase is based on more up to date forecasts of demand and capacity at Heathrow.

4.2.4. The figures in Table 4.2 show the peak hourly load in one direction; which is the estimated near maximum flow in one direction during the summer months. The composition of peak loads is expected to vary during the day, with long haul traffic predominating in the morning and short haul in the evening. The peak loading is the same for both high and low traffic estimates, on the assumption that the peak hour load is limited by the capacity of the Airport. The high traffic figures could therefore be achieved only by spreading peak conditions more evenly through the day.

4.2.5. Table 4.3 shows the expected 1981 distribution of air passengers by geographic area and split between business, leisure, resident and non-resident passengers. The estimates are based on results of surveys carried out in 1966 and 1968. They were adjusted for an expected faster rate of growth among leisure passengers, and a faster growth of hotel capacity in Hammersmith, Kensington and Chelsea than in Westminster and the City.

4.2.6. The total staff working at the Airport in 1966 was just over 37,000, of whom 24,000 were at work on an average day. By 1981, with a total annual air traffic of some 30 million, the staff could number about 60,000 of whom about 40,000 would be working on an average day. With 40 million passengers, the total staff requirement might go up to about 67,000 with about 45,000 working on an average day.

4.2.7. Because of the uncertain nature of "miscellaneous" traffic, that is people other than air passengers and airport staff travelling to and from the airport, estimates are necessarily somewhat arbitrary. The current level of this traffic is about 400,000 a year. For the "coaches only" and BR 1 schemes this has been assumed to double. For schemes BR 2 and BR 3 each link has been assumed to attract half this total flow. With the LT scheme, the numbers of people seeing passengers off has been assumed to increase on the grounds that the check-in point is the place where many people say goodbye. In addition, the lower fares and increased accessibility of the underground system are estimated to increase the number of spectators.

TABLE 4.2

Peak Hour Air Passengers

Year	Total	Link
1966	2,200	—
1968	2,780	—
1974	4,540	3,315
1975	4,840	3,540
1976	5,120	3,730
1977	5,400	3,950
1978	5,700	4,170
1979	6,000	4,390
1980	6,300	4,590
1981	6,600	4,810

TABLE 4.3

Percentage distribution of passengers by origin, journey purpose and residence

	BUSINESS			LEISURE			TOTAL		
	Resident	Non-Resident	Total	Resident	Non-Resident	Total	Resident	Non-Resident	Total
Central Area	4·47	8·64		4·71	15·94		9·18	24·58	33·76
Rest of LTS Area*	6·33	3·08		12·70	7·85		19·03	10·93	29·96
Rest of Metropolitan Area	5·85	·96		6·16	2·39		12·01	3·35	15·36
Rest of U.K.	4·52	2·03		9·77	4·60		14·29	6·63	20·92
Total	21·17	14·71	35·88	33·34	30·78	64·12	54·51	45·49	100·00

*LTS Area—area covered by the London Transportation Study (London and the outer Suburbs).

4.3. *The modal split*

4.3.1. Under each of the proposed schemes, there is a choice in the means of travel to and from the Airport. Associated with each means of transport are certain costs borne by the passenger. The costs he perceives include his time, comfort, and the fares he must pay, as well as a number of additional costs like parking charges or expenses incurred in reaching the railway or underground station. The sum of these costs converted to money terms is called the "generalised cost by a given mode". The relative levels of these costs are expected to influence passengers' choice.

4.3.2. The value passengers place on their time is a function of their income and the purpose of the trip. We took the value of business passengers' time to be their rates of pay. From studies of leisure passengers it appears that they behave as if they value their time at about a quarter of their average hourly earnings which, in general, are somewhat lower than those of business travellers. Generalised costs were therefore computed separately for business and leisure passengers, with time values based on survey data of air passengers' incomes.

4.3.3. These assumptions were tested using information for travel to and from the Airport which the consultants used by TCCL produced in 1966. Generalised costs by both car and airline coach were computed for business and leisure passengers from some 32 different origins in the London area. For car travellers, time costs for both passengers and the driver were included, plus vehicle operating costs, and parking charges. We then made adjustments for occupancy rates and round trip journey. For coach passengers time costs and fares were included, plus the cost of getting to the in-town terminal, which we took as 7*d* per mile (a weighted average of taxi and public transport fares). Because of the difficulty of valuing comfort we did not include this in the generalised costs used in this exercise.

4.3.4. There appeared to be an approximately linear relationship between the modal split from each zone, and the ratio of public to private generalised costs, after the percentage of non-car owners had been accounted for. We therefore used multiple regression analysis, with the generalised cost ratios and the percentages of non-car owners as the independent variables, to find the line of best fit. The use of generalised cost and breakdown into leisure and business passengers provided a better explanation of the observed modal split than had been possible using only time differences. The estimated equation was:—

$$\% \text{ public} = 98 - \underset{(7.8)}{40} \text{ (cost ratio)} + \underset{(0.08)}{0.17} \text{ (\% non-car owners)}$$

The R^2 was 0.5 and the standard errors are shown in brackets below the co-efficient. Both co-efficients are significant at the 95% confidence level.

4.3.5. The relationship we established in that way was then used to predict future modal split under each of the proposed schemes. Values of time were increased for future years to account for the growth in real income, assumed to be at national average rates. Journey times between Heathrow and 64 zones were calculated for both arrivals and departures by each of the possible modes.

Departure times included an allowance for checking-in. The fares adopted were (at 1969 prices) 7*s* for the coach link, 8*s* for BR 3 and 10*s* for BR 1 and BR 2. Standard fares from the appropriate zone plus a 6*d* surcharge were used for the LT link.

4.3.6. The values of passengers' time used in calculating the modal split (in £ per hour) are shown in Table 4.4.

TABLE 4.4

Value of Passengers' Time—£ per hour

Year	Business	Leisure
1968	1·90	0·23
1981	2·87	0·34

4.3.7. Table 4.5 shows some typical travel times between Central London and Heathrow forecast for *1981.*

TABLE 4.5

Typical Travel Times (minutes) between Central London and Heathrow in 1981

	On Arrival		On Departure	
	Heathrow to Westminster	Heathrow to Chelsea	Westminster to Heathrow	Chelsea to Heathrow
By Car	39	28	71	60
By Coach via West London	64	59	95	90
By Coach via Victoria	73	84	111	122
By BR via Victoria (with check-in)	44	55	90	101
By BR via Victoria (without check-in)	44	55	76	87
By LT	51	48	83	80

The times include total travel time including any walking; an allowance for waiting time (which is dependent on the frequency of the coach or train); and time to get to the station or coach stop and between there and the aircraft. The westerly zones favour the coaches from West London and the LT link. From them the Victoria links involve first backtracking to the terminal. Hence the advantage of BR over LT in Westminster is reversed in Chelsea. There are also differences in check-in times which apply to all zones and reflect the varied complexities of the baggage system.

4.3.8. The modal split between car and each of the public links was calculated, using the 1966 calibration. In the absence of any behavioural evidence, we assumed comfort to be the same for all public links. (Its possible effects are dealt with in Chapter 6.) The calibrated equation was thus:—

$$\%\text{ public} = 98—40\left(\frac{\text{Generalised Cost public}}{\text{Generalised Cost private}}\right) + 0.17\ (\%\text{ non-resident})$$

In calculating the numbers choosing public transport in the schemes offering two public modes we have compared private car costs with generalised costs by

the rail link. This does ignore the possibility that there will be a few cases in which the generalised coach costs are lower, and so may understate the number of passengers assigned to public transport. We have not measured the effect of this slight simplification but it is unlikely to be significant, or to affect different schemes differently.

4.3.9. To calculate the relative numbers by coach and by rail for the schemes with two public modes the higher number by the rail link alone was assumed to be the total for both. As there was no observed relationship for a two public mode situation the relationships between cars and coaches was used. The percentage of non-residents was eliminated and a slight adjustment made so that from zones where the generalised costs by either mode were the same 50% would go by each. This procedure attempts to capture the influence of times and fares, assuming equal comfort. Car ownership would not affect the choice between two public links. The equation used was:—

$$\% \text{ coach} = 90 - 40 \left(\frac{\text{Generalised Cost coach}}{\text{Generalised Cost rail}} \right)$$

4.3.10. The results are shown in Table 4.6. The effect of fares and speed means that the LT link would appeal more to leisure passengers, while the BR link has more appeal for business travellers.

4.3.11. The last line of Table 4.6 shows passenger flows for scheme BR 3, which saves some 14 minutes on the departure time. Together with the lower fare of 8*s* this would lead to higher loadings than for the BR schemes which have check-in at Victoria.

4.3.12. We have also considered how airport worker traffic would react to the various schemes. There are at present some 250 trips to work from Central London, and by 1981, there may be some increase. We estimate that the BR 1 scheme, offering a season rate equivalent to £95 a year (again at 1969 prices), would carry a daily average of 285 round trips, giving an annual total of 200,000 one-way trips. The peak hour loading is estimated at 26% of the daily total 75 trips. In schemes BR 2 and BR 3 the rail link is estimated to attract two thirds of the BR 1 total with the rest going by coach.

4.3.13. The LT link would offer a new commuter service for airport workers with enough stops en route to provide an attractive alternative to existing public transport and to cars. The immediate impact which the Piccadilly Line extension would have on the staff journeys covered by the 1966 staff survey for the TCCL report, has been assessed on the basis of a zone-by-zone analysis. From each zone, varying proportions were assigned to the private, LT and other public links based on judgement of the service offered, rather than on a calibrated model like the one used for air passengers.

TABLE 4.6

Annual air passengers by mode (per cent)

SCHEME	COACH		BR		LT		PRIVATE		Charter	Transfer	Total
	Business	Leisure	Business	Leisure	Business	Leisure	Business	Leisure			
Coach only	9·57	21·49					16·72	25·28	8.94	18·0	100·0
LT	4·91	10·33			7·43	17·24	13·95	19·20	8.94	18·0	100·0
BR 1			10·99	20·28			15·30	26·49	8·94	18·0	100·0
BR 2	4·77	10·63	6·22	9·65			15·30	26·49	8·94	18·0	100·0
BR 3	15·39		19·20				38·47		8·94	18·0	100·0

4.3.14. The 1966 modal split figures were then increased in line with the expected growth in the total staff needed to cope with an air passenger flow of 30m. per annum. The ratio of persons in car owning and non-car owning households was adjusted to account for higher car ownership rates in 1981, and applied to the modal splits for the two categories. The modal split figures were also adjusted to account for an assumed long-term effect of staff moving to, and new staff recruited from, areas well served by the Piccadilly Line. A further adjustment was made to account for the inevitable reduction in the convenience of the arrangements made for staff car parking at Heathrow as the number of car commuters grows.

4.3.15. The results of all these calculations are shown in Table 4.7, which is based on a future staff complement of 40,000 on an average day required to deal with 30m. air passengers and giving an annual load of 4.9m. trips on the LT link. With 40m. air passengers, and an expected staff requirement on an average day of 45,000, the annual LT load would be 5.5m. trips. These figures have been used to estimate the annual worker flows on the LT link equivalent to the year-by-year high and low air passenger estimates. Peak hour loadings are taken as 26% of the average daily work force.

4.3.16. The estimates are considerably higher than those used in the TCCL report. This is largely because TCCL assumed that only existing public transport trips around Hounslow would transfer to the underground link. The zone-by-zone analysis we have made suggests that the numbers using the LT link from the whole area might be more than double that suggested by TCCL. And we estimate the cumulative effects of the increased work force, geographical changes and decentralisation of available car parking for workers at the airport to almost double this number again by 1981, even allowing for the effect of increased car ownership.

4.3.17. Annual air passengers by mode for the high traffic estimate are shown in Table 4.8. The figures were derived from the percentage distribution in Table 4.6 applied to the control totals from Table 4.1. The public link passengers from Table 4.8 were then added to the miscellaneous and worker estimates to give the annual public link loadings shown in Table 4.9. Table 4.10 shows peak hour loadings of air passengers by mode. The distribution was assumed to be the same as for the annual loads. The figures for coach peak hour applies to the combined peak load for the West London and Victoria coach systems. Since the peak loads for long haul and short haul traffic do not coincide the sum of the peak loads for these two terminals would be greater than the combined totals occurring at any one time.

4.3.18. Peak hour "miscellaneous" traffic is shown in Table 4.11. The same peak factors were applied as for air passengers, although it is possible that this sort of traffic would spread itself more evenly throughout the day, tending if anything to avoid the commuter peaks. The "miscellaneous" flows are assumed to remain constant throughout the study period, which may well be an overestimate in the earlier years.

TABLE 4.7

Estimates of staff journeys to Heathrow Airport with 40,000 workers on an average day

	1966 SURVEY		1981			
	Without LT Link	With LT Link	Assuming No Change in Circumstances	With car Ownership rate of 80%	With Geographical Redistribution	Adjusted for the effects of decentralised car parking facilities at Heathrow
CAR-OWNING HOUSEHOLDS						
Private	14,649	14,001	23,571	28,405	26,985	26,399
LT Link	—	1,112	1,872	2,256	3,743	4,159
Other Public	1,124	660	1,111	1,339	1,272	1,442
	15,773	15,773	26,554	32,000	32,000	32,000
NON CAR-OWNING HOUSEHOLDS						
Private	3,417	2,992	5,037	2,997	2,847	2,778
LT Link	—	2,512	4,229	2,516	2,790	2,838
Other Public	4,570	2,483	4,180	2,487	2,363	2,384
	7,987	7,987	13,446	8,000	8,000	8,000
TOTAL	23,760	23,760	40,000	40,000	40,000	40,000
LT Link (One-Way Journeys per day)	—	3,624	6,101	4,772	6,533	6,997
LT Link (Total annual journeys) (millions)	—	2·5	4·3	3·3	4·6	4·9

TABLE 4.8

Annual air passengers by mode (thousands—high estimate)

Year	Coach Only		LT			BR 1		BR 2			BR 3			Charter	Trans-fer	Total
	Coach	Other	Coach	LT	Other	BR	Other	Coach	BR	Other	Coach	BR	Other			
1966	3200															10300
1967	—															—
1968	4070															13160
1969	4850															15600
1970	5570															17900
1971	6220															20000
1972	6910															22200
1973	7640															24600
1974	8440	11350	4150	6700	8940									2420	4890	27100
1975	8970	12060	4400	7120	9510	9110	11920	4440	4670	11920	4400	5510	11120	2570	5200	28800
1976	9650	12980	4720	7680	10230	9690	12940	4780	4910	12940	4720	5950	11960	2770	5600	31000
1977	10300	13850	5050	8200	10900	10370	13780	5100	5270	13780	5050	6350	12750	2960	5990	33100
1978	11050	14720	5400	8750	11620	11050	14720	5450	5600	14720	5400	6750	13620	3160	6370	35300
1979	11680	15780	5750	9300	12410	11780	15680	5800	5980	15680	5750	7200	14510	3360	6780	37600
1980	12420	16810	6100	9900	13230	12550	16680	6180	6370	16680	6100	7680	15450	3570	7200	40000
1981	13150	17690	6440	10400	14000	13200	17640	6500	6700	17640	6440	8050	16350	3760	7600	42200

TABLE 4.9

Annual Public passengers (thousands—high estimate)

Scheme	COACH ONLY				LT							
Type	Air Passengers	Misc.	Workers	Total	Air Passengers	Misc.	Workers	Total	Air Passengers	Misc.	Workers	Total
Mode	Coach	Coach	Coach	Coach	Coach	Coach	Coach	Coach	LT	LT	LT	LT
Year												
1974	8440	800	100	9340	4150	320	0	4470	6700	860	4320	11880
1975	8970	800	100	9870	4400	320	0	4720	7120	860	4510	12490
1976	9650	800	100	10550	4720	320	0	5040	7680	860	4700	13240
1977	10300	800	100	11200	5050	320	0	5370	8200	860	4900	13960
1978	11050	800	100	11950	5400	320	0	5720	8750	860	5080	14690
1979	11680	800	100	12580	5750	320	0	6070	9300	860	5260	15420
1980	12420	800	100	13320	6100	320	0	6420	9900	860	5450	16210
1981	13150	800	100	14050	6440	320	0	6760	10400	860	5620	16880

Scheme	BR 1				BR 2							
Type	Air Passengers	Misc.	Workers	Total	Air Passengers	Misc.	Workers	Total	Air Passengers	Misc.	Workers	Total
Mode	BR	BR	BR	BR	Coach	Coach	Coach	Coach	BR	BR	BR	BR
Year												
1975	9110	800	200	10110	4440	410	60	4910	4670	410	130	5210
1976	9690	800	200	10690	4780	410	60	5250	4910	410	130	5450
1977	10370	800	200	11370	5100	410	60	5570	5270	410	130	5810
1978	11050	800	200	12050	5450	410	60	5920	5600	410	130	6140
1979	11780	800	200	12780	5800	410	60	6270	5980	410	130	6520
1980	12550	800	200	13550	6180	410	60	6650	6370	410	130	6910
1981	13200	800	200	14200	6500	410	60	6970	6700	410	130	7240

Scheme	BR 3							
Type	Air Passengers	Misc.	Workers	Total	Air Passengers	Misc.	Workers	Total
Mode	Coach	Coach	Coach	Coach	BR	BR	BR	BR
Year								
1975	4400	410	60	4870	5510	410	130	6050
1976	4720	410	60	5190	5950	410	130	6490
1977	5050	410	60	5520	6350	410	130	6890
1978	5400	410	60	5870	6750	410	130	7290
1979	5750	410	60	6220	7200	410	[illegible]	7740
1980	6100	410	[illegible]	[illegible]570	7680			8220
1981	6440	410		10				8590

TABLE 4.10

One way peak hour air passenger flows

Year	Coach Only		LT			BR 1		BR 2			BR 3			Charter	Transfer	Total
	Coach	Other	Coach	LT	Other	BR	Other	Coach	BR	Other	Coach	BR	Other			
1974	1410	1905	690	1120	1505	0	1905	1410	0	1905	1410	0	1905	405	820	4540
1975	1500	2040	740	1200	1600	1520	2020	750	770	2020	740	910	1890	430	870	4840
1976	1600	2130	780	1270	1680	1610	2120	790	820	2120	780	980	1970	460	930	5120
1977	1680	2270	820	1330	1800	1690	2260	830	860	2260	820	1050	2080	480	970	5400
1978	1770	2400	870	1410	1890	1790	2380	880	910	2380	870	1120	2180	510	1020	5700
1979	1870	2520	920	1480	1990	1890	2500	930	960	2500	920	1190	2280	530	1080	6000
1980	1960	2630	960	1550	2080	1970	2620	970	1000	2620	960	1270	2360	560	1150	6300
1981	2050	2760	1010	1630	2170	2060	2750	1010	1050	2750	1000	1330	2480	590	1200	6600

TABLE 4.11

One way peak hour miscellaneous passenger flows

Coach Only	LT		BR 1	BR 2 and BR 3	
Coach 165	*Coach* 65	*LT* 180	*BR* 165	*Coach* 85	*BR* 85

4.3.19. Peak hour worker traffic is shown in Table 4.12. These estimates are based on the high traffic estimate. The low estimate can be derived by applying the worker/passenger relationships described in paragraph 4.3.15.

4.4. *User Costs*

4.4.1. For public transport users, the direct 'money' costs of the link portion of their trip have been included in the study as the "direct costs" of providing the link. The cost to the community for this part of the trip, in real resources, is therefore the sum of the users' time and comfort costs plus these direct costs which have already been counted in this study. The fares paid are a transfer from the user to the public transport operator and are therefore excluded to avoid double counting. On the other hand the resource costs of the in-town part of the trip to and from the public link terminal (ie the cost to the operator of providing that service) are not included elsewhere in the study. Similarly, for those who go all the way to the Airport by private means, no part of their vehicle costs have been included elsewhere. In each case the real cost is approximately the same as the cost to the user.

4.4.2. There is no generally agreed method of valueing some of these costs, like comfort and convenience. There are of course differences between the schemes involving eg the provision of check-in facilities or the convenience of interchange. In the modal split calculations, it was assumed that the net effect of all these factors did not affect the choice between the various schemes. The remainder of this section will deal solely with those items that have been valued in money terms. The unquantified costs and benefits are discussed in Chapter 7.

4.4.3. There are then three main types of user cost reduction which are not included elsewhere:—

i. time savings;

ii. reduction in costs for users of the public links on the non-link part of their trip;

iii. reduction in private resource costs (other than time) for travellers switching from private to public transport.

4.4.4. Business travelling time was valued at £1.9 per hour in 1968 increasing at 3.25% per annum. This was based on the average income of air travellers in 1968, and the expected increase in national average real wages. It may be an overestimate for two reasons:—

i. it assumes that all business travellers in fact travel in business time, so imposing a resource cost on the community equal to the value of that time. That is by no means certain. Some may be travelling in their own time which would be valued at a lower rate.

ii. the assumed increase in the value of time at 3.25% per annum may be unrealistic. Much of the growth in air travel may be in groups having lower incomes than today's air passengers. The average value of air travellers' time may not therefore rise at the same rate as the national average income. This is very important in this study because of the high

proportion of business travellers (36%); much greater than in most transport studies. The values used have therefore been subjected to detailed sensitivity testing. (See Chapter 6.)

4.4.5. For evaluation (as opposed to prediction) a national average value of leisure time (£0.163 per hour in 1968 increasing at 3% per annum) was used. This is the national average value of time used by the Ministry of Transport in all its studies. It is lower than the value used in the modal split calculations, which are based on the actual incomes of air travellers.

4.4.6. The leisure time value we used is very close to that in the 1967 TCCL report, but our business value used is more than three times as high. The TCCL study adopted an average wage rate for London rather than one specific to air travellers on business. That study also assumed a slower rate of growth in the value of time. So the value of time savings for all four schemes in this study are considerably higher than in the TCCL report.

4.4.7. In assessing the benefits of shorter journey times it is important to distinguish between traffic which would use public transport whether the quicker service is introduced or not, and traffic which is induced to use public transport because of the reduction in costs from the introduction of the new link. Clearly the benefits to the former are equal to the time saving between the old travel time and the new. But it would be wrong to consider the whole of the difference between the old and new travel times as a benefit to generated traffic. That these people do not use the present system of public transport implies that the trip is not worth their while. But a small reduction in time may have been enough to persuade some of them to use the new link. Others would need virtually the full reduction in travel time before moving over to the new link. If there is a normal distribution between these two extremes, we can assume that the aggregate benefits to generated traffic are half the difference between the old and new travel times.

4.4.8. We then calculated reductions in in-town operating costs. For journeys starting outside the LTS area we have assumed a standard cost of 3.5d. per mile as the cost of reaching the in-town terminals, on the arbitrary assumption that all out-of-town travellers would use public transport for that part of their trip. As this section of the journey would be the same as for those taking the LT link to the Airport no differential operating costs would arise as between schemes. For those coming from inside the LTS area we assumed that some travellers would use taxi or car to reach the in-town terminals. The weighted average cost for all users was taken as 7d. per mile for these trips. As users of the underground would be travelling over the same distances at a rate of 3d. per mile, we attributed only the cost saving of 4d. per mile. For schemes BR 2 and BR 3 the same mileage rate of 7d. per mile would apply, and the difference in actual miles travelled has been valued at this rate on the basis of approximately the same split of taxi, car and underground for getting to and from the BR and coach terminals.

4.4.9. The savings calculated in this way are real resource cost savings which, unlike the operating costs of the links themselves, have not been taken into account in the cost side of the analysis. As in the case of time, we counted the full saving as being attributed to existing users, and half the saving to those diverted from private transport.

TABLE 4.12

One way peak hour worker flows

Year	Coach only	LT		BR 1	BR 2 and BR 3	
	Coach	Coach	LTB	BR	Coach	BR
1974	35	0	1600	75	25	50
1975	35	0	1670	75	25	50
1976	35	0	1740	75	25	50
1977	35	0	1820	75	25	50
1978	35	0	1880	75	25	50
1979	35	0	1950	75	25	50
1980	35	0	2030	75	25	50
1981	35	0	2080	75	25	50

TABLE 4.13

Time saved by Existing and Diverted Travellers

			Annual Trips	Time Saved Per Trip	Total Time Saved	Value of Time Saved 1981
			(000)	(Mins)	(000 Mins)	(£000)
					LT	
Business	Existing	*arrivals*	1404	16·5	23128	1110
Business	Existing	*departures*	1822	17·1	31285	1500
Business	Diverted	*arrivals*	545		11132	270
Business	Diverted	*departures*	384		8429	200
Leisure	Existing	*arrivals*	3450	17·5	60408	243
Leisure	Existing	*departures*	3778	17·9	67907	271
Leisure	Diverted	*arrivals*	1052		21098	42
Leisure	Diverted	*departures*	864		18093	36
					BR 1	
Business	Existing	*arrivals*	1404	21·2	29727	1430
Business	Existing	*departures*	1822	7·5	13745	660
Business	Diverted	*arrivals*	410		10258	246
Business	Diverted	*departures*	66		1921	46
Leisure	Existing	*arrivals*	3450	21·5	74271	297
Leisure	Existing	*departures*	3770	7·9	29897	119
Leisure	Diverted	*arrivals*	—119		—1163	—2
Leisure	Diverted	*departures*	—279		—791	—2
					BR 2 and 3	
Business	Existing	*arrivals*	1404	21·2	29727	1430
Business	Existing	*departures*	1822	21·5	39260	1880
Business	Diverted	*arrivals*	458		11290	272
Business	Diverted	*departures*	299		7904	190
Leisure	Existing	*arrivals*	3450	21·5	74271	297
Leisure	Existing	*departures*	3778	21·6	82788	330
Leisure	Diverted	*arrivals*	217		5987	12
Leisure	Diverted	*departures*	173		5238	10

4.4.10. People switching from cars to public transport also save by not using their cars all the way to the Airport. Savings in time and in-town costs have already been included. The rest of the saving is equivalent to the mean of the fares charged on public transport before and after the improvement multiplied by the number who switch. This is called the *fare equivalent* in Table 5.1. The resource costs used in carrying them by public transport have been picked up in the operating costs of each link, for which they pay the public transport fare. If this were not included as a cost reduction, we would be in effect charging the resource costs both in travelling by car and public transport for the same trips.

4.4.11. Table 4.13 illustrates the order of magnitude of time savings for the various schemes. The figures shown are based on an annual turnover of 34 million passengers, somewhere between the high and low traffic estimates. The possibility of error in time estimates is much less between the BR and LT systems than the absolute differences of both of these compared to coach. The section on sensitivity shows the effects of assuming different coach journey times and check-in times in BR 1 and BR 2. Although the total time savings of leisure passengers are much greater than for business traffic, the benefits are less because of the differences we have assumed in the values of time. It is most important to test the sensitivity of these rates, and we have done so carefully. The results are in Chapter 6.

4.5. *Indirect Costs*

4.5.1. The two main categories of indirect cost are the effects on other passengers on the LT link due to the additional airport traffic particularly in the commuter peaks, and congestion costs experienced by road traffic due to the level of airport traffic on the roads. The question of crowding on the Piccadilly Line is considered separately as an "unquantified" factor because its effects cannot be expressed in money terms on any generally agreed basis. But there are well established techniques for measuring road congestion costs.

4.5.2. All the schemes involving a rail link would reduce the total amount of road mileage travelled by airport users because:—

i. more people would go to the Airport by public transport producing some saving on car trips.

ii. the mileage travelled to the in-town terminals depends partly on where they are. For example, road mileage is significantly reduced in the case of the LT link because people will join the system at their nearest station rather than travel to some central point before boarding.

4.5.3. The mileage travelled from the three main origin areas is shown in Table 4.14, against the areas through which they will travel. The "glue pot" ring bounds the area outside the Central Area, but within a radius of about three miles from Charing Cross, which has been identified as an area of second degree road congestion (ie less than in the Central Area, but more than for the rest of the London area). The mileage reductions shown in the bottom row of Table 4.14 are the differences between the scheme shown, and the coaches only scheme, together with a small adjustment to account for the additional road capacity around the in-town terminals described in paragraph 4.6.9.

4.5.4. The reduction in road miles travelled by airport passengers increases the amount of road space available for everyone else. This in turn increases average journey speeds and creates a time saving for all road users. The method used to calculate this time and cost saving is based on a comparison of junction delays with and without the reduction in road mileages. This method assumes that the capacity of an urban road system is determined by junctions and not by links. With system loadings at or below junction capacity, journey speeds are relatively constant. As loadings increase above junction capacity, queues begin to form and some motorists are required to wait through more than one signal.

4.5.5. At present, it is estimated that Central Area and "glue pot" area junctions are overloaded by 5% at the peak hours. It is possible to calculate the average peak period delay at each junction, using a formula developed by the Ministry of Transport (Cmnd. 3686—"Transport in London"—Appendix J). By applying the reduction in road mileage to the existing road mileage it is then possible to calculate a new percentage overload per junction. From this, the new average delay per passenger car unit per junction is calculated, and multiplied by the capacity of each junction times the number of junctions gives the change in delay for all remaining motorists. The total time savings are then multiplied by the value of time for road users, to give the total congestion cost saving.

4.5.6. Table 4.15 shows the annual costs for the central and "glue pot" areas for the years 1974, 1981 and 1994, for each scheme against the "coaches only" scheme. These figures assume that the initial overload of 5% will stay constant throughout the period. This assumption depends largely on a workable restraint programme and could well underestimate the benefits. Congestion savings have not been included for the inter-urban roads or the rest of the LTS even though the mileage reductions are quite substantial for some schemes. In the former case, they are small compared to the overall mileage and the junction method does not apply. In the latter case, the existing overload is difficult to determine, and since much of this mileage would be on the M4, again the junction method is less accurate. The net effect of all this is that all the congestion cost savings may well be understated.

4.5.7. The sum of the discounted annual costs is also shown in Table 4.15. It could be argued, however, that some of the road space made available would be taken up by new car trips. This would tend to reduce the change in overload, and hence the cost savings. We have therefore assumed a notional reduction of 50% in all the congestion cost savings. There would in theory be some benefit to those making the new trips, but this would be very small in relation to the total and has therefore been ignored.

4.6. *Direct Costs*

4.6.1. All costs have been based on 1969 price levels, with labour costs assumed to increase at 3% per annum. Only direct construction costs for the rail links and associated termini have been included in the years from 1970 to 1973. Up to this point, coaches only would continue to operate as at present. The costs for this operation would be common to all schemes and have therefore not been

TABLE 4.14

Peak period (1.5 hrs) PCU miles by area 1981—A.M.*

Area passed through

	Coaches Only				LT				BR 1				BR 2				BR 3			
	Central Area	Glue Pot Area	Rest of LTS	Inter-Urban	Central Area	Glue Pot Area	Rest of LTS	Inter-Urban	Central Area	Glue Pot Area	Rest of LTS	Inter-Urban	Central Area	Glue Pot Area	Rest of LTS	Inter-Urban	Central Area	Glue Pot Area	Rest of LTS	Inter Urban-
By Private Vehicles																				
From Central Area																				
Home to Heathrow	1121	2242	7847	0	785	1570	5496	0	1141	2282	7987	0	1141	2282	7987	0	960	1920	6721	
Home to Town Terminal	612	0	0	0	597	0	0	0	612	0	0	0	603	0	0	0	679	0	0	0
From rest of LTS Area																				
Home to Heathrow	0	0	13566	0	0	0	10220	0	0	0	13118	0	0	0	13118	0	0	0	11835	0
Home to Town Terminal	174	347	1215	0	35	70	243	0	183	366	1282	0	182	364	1275	0	206	411	1440	0
From rest of U.K.																				
Home to Heathrow	0	0	0	76429	0	0	0	68218	0	0	0	76149	0	0	0	76149	0	0	0	72839
By Coaches																				
Total Study Area																				
Town Terminal to Heathrow	187	373	1307	0	89	178	624	0	0	0	0	0	93	185	648	0	92	184	645	0
Total PCU miles	2094	2962	23935	76429	1506	1818	16583	68218	1936	2648	22387	76149	2019	2831	23028	76149	1937	2515	20641	72839
Less mileage covered by roadworks	1846	2962	23935	76429	1380				1541				1698				1616			
Less coaches only	0	0	0	0	—466	—1144	—7352	—8211	—305	—314	—1548	—280	—148	—131	—907	—280	—230	—447	—3294	—3590

*P.C.U.—Passenger Car Unit. This term enables the capacity of a highway, or the volume of a stream of traffic, to be expressed in terms of a single number whic[h] is independent of the composition of vehicles in a traffic stream. It allows for the different effect of various types of vehicle by considering them in terms of the equivalen[t] number of passenger cars.

TABLE 4.15

Congestion costs Central and GluePot areas (£000)

	LT			BR 1			BR 2			BR 3		
	Central Area	Glue Pot Area	Total	Central Area	Glue Pot Area	Total	Central Area	Glue Pot Area	Total	Central Area	Glue Pot Area	Total
Annual congestion costs 1974	– 156	– 146		– 114	– 55		– 74	– 30		– 94	– 67	
1981	– 285	– 240		–192	– 82		– 128	– 53		–155	– 104	
1994	– 421	– 352		– 283	– 120		– 189	– 77		– 229	– 153	
Sum of discounted annual costs (full value)	–1,710	–1,600		–1,248	– 605		– 810	– 330		–1,024	– 735	
Sum of discounted annual costs (half value)	– 850	– 800	–1,650	– 624	– 302	– 926	– 405	– 165	– 570	– 512	– 368	– 880

included. Given an early decision to build, the LT link could begin operation early in 1974, and the BR schemes by 1975. From 1974 onwards all costs have been included year by year for both the high and low traffic estimates. For the LT scheme the 1974 costs of operating the joint coach and tube operation have been included. For all the other schemes the 1974 costs of the coach services have been included.

4.6.2. Capital costs for the coach operations were derived from peak hour flows for the coach stock. The operating costs were based on forecast annual route miles. These annual operating costs vary considerably between the high and low estimates and account for the major proportion of the total costs. The cost estimates for coaches are approximately 30% higher than those estimated in the TCCL study for comparable traffic flows. The TCCL report estimated costs on the basis of all coaches operating from a single West London Terminal. In the present study the costs are based on operation of the individual airlines from separate terminals. The resulting lower load factors explain much of the difference between the two studies.

4.6.3. The rail portions of the costs were estimated by LT and BR respectively The LT capital costs have increased only marginally over their original estimates for the TCCL study and this can be explained largely by price increases since 1966. The costs submitted by LT for fixed track and platform and shown in Table 5.1 include a portion of the Heathrow station structure and hence are not directly comparable with the BR estimates for the same item. The LT operating costs are approximately 60% higher than those estimated in the TCCL study. But because they form only a minor part of the total cost the increases have little effect on the overall picture.

4.6.4. The BR estimates of capital costs for the link are about 20% higher than estimated in the TCCL report. Much of this is due to the more precise costing which has taken place since 1967 of the track and signalling system needed.

4.6.5. The capital costs of the BR 2 scheme are slightly less than BR 1, mostly due to reductions in rolling stock requirements. Rolling stock costs are even less in the BR 3 scheme because the twenty baggage cars would not be required. There are also marginal differences in track and platform costs between the three BR options.

4.6.6. As with the LT link, the BR link operating costs estimated at 1969 prices have increased but to a very much greater extent, some 140% more than the TCCL estimates. These increases are partly the result of price increases and partly of the more detailed study BR have made in the interim. These costs too vary between the BR options largely in relation to the variation in rolling stock required.

4.6.7. The costs of all four rail links are not affected by the level of traffic between our high and low estimates.

4.6.8. The central terminal costs at the Airport include passenger conveyors to all three departure buildings under the LT and BR 3 schemes, but only to the longer distance terminal in the other BR options. This was based on the assumption that BR passengers would be without luggage in schemes BR 1 and BR 2, while LT and BR 3 passengers would be carrying their bags. But the airlines have always insisted that passenger conveyors to all three terminals are an essential feature of any scheme. The costs of this alternative arrangement, together with possible complementary variations in the baggage handling system, have been subjected to sensitivity tests. In addition, the effect of possible minor roadworks (perhaps a pedestrian foot-bridge), made necessary by the station at Hatton Cross, has also been tested.

4.6.9. The costs of new roadworks necessary to improve traffic circulation around the in-town terminals and the Airport have also been included. We have costed the roadworks necessary to meet future traffic loads of airport and non-airport motorists, and then applied a portion of the costs of these road schemes to each scheme, based on the ratio of airport to non airport use. "Airport use" was taken to include traffic associated with the coach and the BR terminals. The results are relatively insignificant and do not vary appreciably from the estimates in the TCCL report. A summary of all costs, user, indirect, and direct is in Table 5.1 (which is based on our high air traffic estimates). The numbers shown are the present values of the sum of discounted costs from 1970 to 1994 for each of the items listed. Depreciation of capital has not been included as a cost; all capital items have been depreciated on a straight-line basis over their book lives and the remaining value at 1994 treated as a reduction in cost. Those items which become life-expired during the period have been charged renewal costs in the appropriate year, and the depreciation and residual value procedure has been repeated from there. Book lives for all schemes have been used, based on BR practice, to place everything on the same basis.

5. THE RESULTS

5.1. *The Cost-Benefit Results*

5.1.1. Table 5.1 shows the total present value of both capital and annual costs for each scheme. Negative figures represent cost savings (benefits). The bottom line gives the ratio of the sum of discounted annual cost changes over the additional capital cost. This figure is in effect the ratio of net benefits to outlay given a discount rate of 10%.

5.1.2. The LT scheme shows much the highest total return, and the highest return per pound invested. On the basis of these figures, the best BR scheme is BR 3. The BR 2 scheme with check-in at Victoria is the only scheme which fails to produce benefits as great as its costs.

TABLE 5.1

Cost-benefit summary high traffic estimate (£000)

	COACHES ONLY		LT		BR 1		BR 2		BR 3	
	Capital	Annual	Capital	Annual	Capital	Annual	Capital	Annual	Capital	Annual
1. USER COSTS										
(1) AIR PASSENGERS										
Existing Public Transport Users										
Business Time		0		—19,195		—14,300		—14,300		—24,200
Leisure Time		0		— 3,760		— 2,850		— 2,850		— 4,610
In-Town Costs		0		— 1,380		+ 27		+ 27		+ 27
Sub Total		0		—24,335		—17,123		—17,123		—28,783
Diverted from Private Vehicles										
Business Time		0		— 3,347		— 2,033		— 2,033		— 3,373
Leisure Time		0		— 566		+ 15		+ 15		— 164
In-Town Costs		0		— 366		— 5		— 5		— 5
Fare Equivalent		0		— 6,007		— 218		— 218		— 3,040
Sub Total		0		—10,286		— 2,241		— 2,241		— 6,582
(2) AIRPORT WORKERS										
Existing Public Transport Users										
Commuter Time		0		— 574		0		0		0
Operating Costs		0		—		0		0		0
Sub Total		0		— 574						
Total Users Costs		0		—35,195		—19,364		—19,364		—35,365
2. INDIRECT COSTS Total (congestion)		0		— 1,650		— 926		— 570		— 880
3. DIRECT COSTS										
(1) Link										
Airline coaches and depot	765	18,281	211	8,881	—79	1,427	298	10,038	255	9,459
Rail rolling stock and depot			382		2,153	1,764	1,525	1,455	1,310	1,320
Rail fixed track and station platform			10,795	1,542	13,045	3,651	12,946	3,284	12,500	2,580
(2) Town Terminals										
Coach Terminals and check-in operation	391	7,298	0	5,650	-1,140	0	0	5,650	0	5,650
Victoria Terminal and check-in space					6,345	4,661	4,987	3,686	39	0
Victoria check-in airline equipment and staff					148	7,150	111	4,050	0	0
(3) Heathrow Terminals and distribution system			1,882	1,127	3,245	1,953	3,074	1,662	2,640	1,010
HR Flight Terminals and check-in space	26	0	447	197	0	0	13	0	447	197
HR check-in airline equipment and staff				1,630						1,630
Sub Total Link and Terminals	1,182	25,579	13,717	19,027	23,717	20,606	22,954	29,825	17,191	21,846
(4) Road Works										
Road works around Victoria BR & BOAC terminals	465		239		749		623		623	
Road works West London	68		0		0		0		0	
Road works Airport	355		0		169		169		169	
Airport parking	0		0		0		0		0	
Sub Total Roads	888		239		918		792		792	
Total Direct Costs	2,070	25,579	13,956	19,027	24,635	20,606	23,746	29,825	17,983	21,846
Total All Costs	2,070	25,579	13,956	—17,818	24,635	316	23,746	9,891	17,983	—14,399
Less Coaches Only	0	0	11,886	—43,397	22,565	—25,263	21,676	—15,688	15,913	—39,978
Total Cost (Net present Value)				—31,511		—2,698		5,988		—24065
Ratio of Discounted Annual Cost Reduction to additional capital				3·65		1·12		·73		2·50

+represents an increase in costs

—represents a reduction in costs

5.1.3. The results can best be appreciated from an analysis of the detail. Considering first of all the direct costs, the "coach only" scheme has low capital requirement but quite high annual operating costs. A further capital investment of £11.9m (in present value terms) to add the LT link would produce savings of £6.6m in the present value of operating costs for the reduced coach service then required. This would leave £5.3m to be covered by additional benefits in order to break even on a cost-benefit basis. With BR 1 the extra capital cost over and above the cost of the coach service would be £22.6m, which would produce a saving of £5.0m in operating costs leaving £17.6m to come from other benefits. The BR 2 scheme would cost more than the coaches in both capital and annual terms. Scheme BR 3, for an additional capital investment of £15.9m would produce an annual saving equivalent in present value terms to £3.7m leaving £12.2m to be recouped.

5.1.4. Time savings, and business time in particular, make up much the largest portion of the quantified benefits. Due to the check-in delays on departures in schemes BR 1 and BR 2, the BR 3 scheme (without check-in) scores highest on this count, with LT second. This advantage is however largely offset by the benefits to diverted traffic in terms of saving of private resource costs (called the Fare Equivalent in the tables), which the LT scheme achieves.

5.2. *The Financial Assessment*

5.2.1. Financial Assessments for the rail link portions of the various schemes are shown in Table 5.2. Costs for all items directly associated with the rail links such as terminal buildings and the internal airport distribution system have been included. We did so to place all schemes on a comparable basis, but that does not imply that the full costs should be met from rail revenue.

5.2.2. Air passenger revenues for the BR options with check-in are based on the 10s fare. For the BR 3 option the fare is 8s. Miscellaneous revenue for all three BR options is based on a day return fare of 15s. BR worker revenue is based on a season ticket at a rate equivalent to £95 a year. Revenue at Victoria is based on BR's estimates of check-in rental from the airlines and miscellaneous concessions. A contribution of 1s per passenger from Gatwick passengers, who would also use the Victoria Terminal has been included, as has some estimated extra revenue from generated traffic on BR services between Victoria and passengers' "home" stations.

5.2.3. Air passenger revenue for LT is based on the sum of the number of passengers from each zone times the fare from each zone. We then reduced that figure by an amount equal to the revenue LT would receive in a "coaches only" situation from passengers taking LT services to the coach terminal, assuming that 25% of passengers would go to and from the coach terminals by public transport. Their passenger revenue was also reduced by 2% to account for the shut down of the LT service during the small hours. We also deducted LT's loss of revenue on their bus service between Hounslow and Heathrow. The result is the extra revenue arising from the building of the link. Miscellaneous passengers were based on an average fare of 4s 3d; staff revenue on an average fare of 2s 3d per journey. Revenue from internal airport journeys was based on a fare of 1s per journey with traffic the same as estimated in the TCCL report.

TABLE 5.2

Heathrow link financial assessment 1975 and 1985 (£000)

	Rolling Stock	Fixed Track	Victoria Terminal	Airport Cent. Terminal	Airport Flight Terminal	Total 1975 High	Total 1985 High	Rolling Stock	Fixed Track	Victoria Terminal	Airport Cent. Terminal	Airport Flight Terminal	Total 1975 High	Total 1985 High
Outlays				LT							BR 1			
Capital Outlay	500	13500	0	2454	500	16954		3000	17020	8220	4080	0	32320	
Capitalized Interest during Const. 10%	20	1831	0	195	0	2046		250	3377	1590	775	0	5992	
Total	520	15331	0	2649	500	19000	—	3250	20397	9810	4855	0	38312	—
Costs														
Interest on Outlay 10%	52	1533	0	265	50	1900	1900	325	2040	981	486		3831	3831
Amortization 10% Sinking Fund	5	30	0	10	15	60	60	29	54	41	38	0	162	162
Working Expenses (1975)		214	0	155	25	394		259	569	702	294	0	1824	
Working Expenses (1985)	—	254	0	187	34		475	325	658	851	357	0		2191
Total						2354	2435						5817	6184
Revenue														
Passengers						1749	2558						4625	6783
Miscellaneous						184	184						300	300
Workers						509	635						10	10
Concessions and Rentals Victoria Terminal						0	0						215	215
Internal Airport Traffic						27	31						0	0
Commuters						66	66						0	0
Gatwick Services						0	0						126	208
Loss on Red Arrow Services						—95	—95						0	0
Total						2440	3379						5276	7516
Excess of Revenue over Costs						+86	+944						—541	+1332
Rate of Return (25 years)				11.5%							9.9%			
Outlays				BR 2							BR 3			
Capital Outlay	2125	16875	6370	3890	0	29260		1840	16350	50	3330	500	22070	
Capitalized Interest during Const. 10%	180	3377	1459	756	0	5772		155	3285	0	652	0	4092	
Total	2305	20252	7829	4646	0	35032		1995	19635	50	3982	500	26162	
Costs														
Interest on outlay 10%	231	2025	783	465		3503	3503	200	1964	5	398	50	2616	2616
Amortization 10% Sinking Fund	19	52	31	29	0	131	131	16	50	0	6	15	87	87
Working Expenses (1975)	213	514	556	253	0	1536		193	405	0	155	25	778	
Working Expenses (1985)	269	591	673	303	0		1836	244	465	0	187	34		930
Total						5170	5470						3481	3633
Revenue														
Passengers						2400	3443						2281	3332
Miscellaneous						152	152						152	152
Workers						6	6						6	6
Concessions and Rentals Victoria Terminal						215	215						0	0
Internal Airport Traffic						0	0						0	0
Commuters						0	0						0	0
Gatwick Services						126	208						0	0
Loss on Red Arrow Services						0	0						0	0
Total						2899	4024						2439	3490
Excess of Revenues over extra cost						—2271	—1446						—1042	— 143
Rate of Return (25 years)				2.0%							6.5%			

Revenue from additional London commuters has also been included. LT estimate that the link will attract an extra 800 commuters from Hatton Cross at a season ticket rate equivalent to £83 per annum.

5.2.4. Table 5.2 shows normal cash accounts for the years 1975 and 1985 on the basis of our high traffic estimates. Amortization and depreciation were calculated using the sinking fund technique as opposed to the straight-line depreciation and residual value method used in the cost-benefit analysis. Interest on capital during construction was compounded, beginning with the second year following the year of expenditure. This procedure differs slightly from BR audit accounting practice.

5.2.5. Table 5.3 shows the financial implications to the airlines of the various schemes. The figures are based on a discount rate of 10%. They apply only to actual coach operation, any effects on terminal operation being ignored. In scheme BR 1, where the coach services shut down, the return to the airlines would arise simply from the resale value of their coaches.

TABLE 5.3

Financial Assessment Coach Operations (£000)

	Coaches only	LT	BR 2
	High	*Traffic*	
Present Value of Future Costs	19117	9133	10383
Present Value of Future Receipts	28070	13480	15073
Net Present Value	+8953	+4347	+4690
	Low	*Traffic*	
Present Value of Future Costs	15121	7151	8248
Present Value of Future Receipts	21942	10510	11870
Net Present Value	+6821	+3359	+3622

N.B.—Financial effects of coach operations with Scheme BR 3 are within the range bounded by LT and BR 2

6. SENSITIVITY TESTS

6.1. *The Method*

6.1.1. In arriving at our results we had to make various assumptions, some or all of which might affect the comparison. We therefore tested our results by reworking the figures on the basis of the most extreme assumptions that seem to us to be within the bounds of possibility. Changes in general assumptions, such as forecasts of future air traffic, affect all the schemes in the same way, so that it would not be right to compare the figures for one scheme at, for example, high air traffic assumptions with another at low ones. Other assumptions, such as estimates of costs of construction, can affect individual schemes differently. We attempted to assess the best and worst credible combinations of all the assumptions.

6.1.2. The *best* general assumptions for all the rail links would be:—

i. Our high air traffic estimate

ii. Higher values of business time (as used by the Commission on the Third London Airport in "Papers and Proceedings", Volume VII, page 231—HMSO 1970).

iii. The very slow coach journey times we have adopted.

6.1.3. The *worst* general assumptions for the rail links would be:—

i. Our low air traffic estimate

ii. Valuing business time at, say, half the value used in the original calculation. It can be argued that all travel for business *purposes* may not be on business *time*, and hence should not be valued at the wage rate. We did not find it necessary to come down on either side of this argument, because our tests showed that the ranking of the four schemes is not sensitive to any lower value of business time.

iii. An average coach journey time 5 minutes faster than we estimated in the original calculations.

6.1.4. In the comparisons between LT and BR 3, the best general assumptions exclude any penalties for lack of check-in. The worst general assumptions include a penalty charge of 2s per departing trip on both links to represent a possible disbenefit for lack of that facility.

6.1.5. In the comparison between LT and BR 1 and BR 2, the best specific assumptions for the BR schemes are:—

i. There is an additional benefit because of the option of check-in at Victoria which is equal to the time (14 mins) that doing so adds to the journey.

ii. The means of travel to the Victoria terminal will be in the proportion of 70% by public transport to 30% by private transport (the situation at the coach terminals now is just the reverse). This meets the argument that Victoria is more ideally located for public transport than the present coach terminals. It is slightly more than the proportion of weekend travellers passing through Victoria who use public transport today. This upper limit increases the in-town cost savings attributable to the BR links.

6.1.6. The *worst* assumptions for BR are:—

i. There is no advantage in having the option of in-town check-in.

ii. The means of transport used to get to Victoria will follow the same pattern as that observed at the coach terminals now.

iii. The re-sale value of the coach terminals (in the case of BR 1) is one quarter that assumed in the original calculations.

iv. A contingency allowance of £0.5m should be added to the direct costs to allow for unresolved problems associated with the baggage handling system.

6.1.7. All other assumptions remain unchanged in both "best" and "worst" cases.

6.1.8. The *best* specific assumptions for LT in the comparisons with BR 1 and BR 2 are the same as in the original calculations, except that the costs have been reduced by £0.4m; the cost of the extra passenger conveyors at Heathrow which were not included in the BR 1 and BR 2 schemes.

6.1.9. The *worst* specific assumptions for LT are:—

i. A penalty of 2s per departing passenger has been charged to represent a user disbenefit for lack of check-in at the in-town end. In addition a comfort charge equivalent to 1s of user costs per passenger has been added to represent relative lack of comfort on the LT link. This is an extreme position. Only about 6% of air passengers will in fact be subject to crowding, and perhaps 2% will fail to find a seat on boarding; and then only at peak times, when travelling with the commuter flow.

ii. Direct costs should be increased by £0.5m to allow for contingencies, particularly possible extra roadworks connected with the Hatton Cross station. And direct costs should be increased by £0.16m capital and £0.095m annual (in present value terms) to allow for one extra LT train per peak. (It should be noted that to add a further five trains in each peak hour—the operational limit—would not significantly affect the relative costs of the 4 schemes.)

6.1.10. In the comparisons with LT and BR 3, the *best* specific assumptions for BR include:—

i. The favourable split of 70% public transport and 30% private among passengers arriving at Victoria. This would increase the savings both in congestion costs, and in-town operating costs.

ii. A road cost sharing formula based on proportions of evening peak travel, which reduces considerably the cost difference between BR and LT.

6.1.11. The *worst* specific assumptions for BR 3 include:—

i. A contingency cost allowance of £0.5m to cover the possibility of extra expense, particularly in providing access for taxis, at Victoria.

ii. A 5 minutes penalty on departures because the 10 minute service might cause more uneven flows through the Airport check-in system than would LT's more frequent trains.

iii. Road costs have been allocated on the basis of a more comprehensive road scheme at Victoria, based on the proportions of morning peak traffic, which generally favours LT.

6.1.12. The *best* specific assumptions for LT include:—

i. No comfort penalties for crowding

ii. Direct cost reductions as in paragraph 6.1.8 above

iii. Double the original estimates of congestion cost saving

iv. The road cost sharing formula in paragraph 6.1.11.

6.1.13. The *worst* specific assumptions for LT include:—

i. A 1s charge on all passengers to represent relative lack of comfort

ii. Additions to direct costs, to allow for contingencies and one extra train (as in paragraph 6.1.9. above)

iii. The road cost sharing formula in paragraph 6.1.10.

6.1.14. In calculating values for these tests the various comfort charges and time changes were first run through the modal split model. User costs were then recalculated on the basis of the new traffic totals allocated to each link.

6.1.15 Total traffic by each link for the year 1981 is shown in Table 6.1, opposite the test codes to which they apply. We included the comfort charges as resource cost penalties to users at their full value. Table 6.2 shows a more complete break down of the air passenger user costs which are summarised in Tables 6.3, 6.4, 6.5 and 6.6.

6.2. *The Results*

6.2.1. Comparisons between LT and BR 3 are shown separately from the comparison between LT and BR 1 and BR 2 since the absence of in-town check-in is a common ingredient in the first case, but not in the second. The benefit-cost ratios shown in Tables 6.7 and 6.8 were taken from Tables 6.3, 6.4, 6.5 and 6.6. These tables show the main assumptions made for each of the sensitivity codes shown. In the bottom half of these tables, the values of the main cost items from which the ratios were calculated are shown. The original calculations are also shown for ease of comparison.

Table 6.1

Rail passengers 1981 (000)

LT = 10,400	BR 1 = 13,200	BR 2 = 6,700	BR 3 = 8,050
(A) = 10,400	(A) = 13,660	(A) = 7,200	(A) = 8,050
(B) = 9,280	(B) = 13,200	(B) = 6,700	(B) = 7,790
(C) = 7,770	(C) = 10,200	(C) = 5,350	(C) = 5,550
(D) = 6,900	(D) = 9,860	(D) = 5,000	(D) = 5,550
(E) = 9,600			
(F) = 10,600			
(G) = 6,900			
(H) = 6,900			

Table 6.2

User costs sensitivity (in 000s)

	LT	LT (F) LT (A)	LT (B)	LT (C)	LT (D) LT (H) LT (G)	LT (E)	BR 1 BR 2	BR 1 (A) BR 2 (A)	BR 1 (B) BR 2 (B)	BR 1 (C) BR 2 (C)	BR 1 (D) BR 2 (D)	BR 3	BR 3 (A)	BR 3 (B)	BR 3 (D)	BR 3 (C)
Existing Business Time	—19195	—19800	—19800	— 5100	— 5100	—19800	—14300	—25000	—14800	— 5760	— 3420	—24200	—25000	—21600	— 6000	— 6000
Leisure Time	— 3760	— 3760	— 3760	— 2000	— 2000	— 3700	— 2850	— 4610	— 2850	— 2200	— 1360	— 4610	— 4610	— 4100	— 2350	— 2350
In-Town Costs	— 1380	— 1380	— 1380	— 1060	— 1060	— 1380	+ 27	— 690	+ 27	— 1690	+ 27	+ 27	— 690	+ 27	+ 27	— 690
Diverted Business Time	— 3347	— 3450	— 3180	— 890	— 820	— 3300	— 2033	— 3150	— 2100	— 730	+ 490	— 3370	— 3480	— 2960	— 780	— 780
Leisure Time	— 566	— 566	— 406	— 300	— 215	— 496	+ 15	+ 15	+ 15	+ 6	+ 6	— 164	— 164	— 133	— 26	— 26
In-Town Costs	— 366	— 366	— 282	— 280	— 215	— 321	— 5	— 5	— 5	— 5	— 5	— 5	— 5	— 8	— 16	— 16
Fare Benefit	— 6007	— 6007	— 4410	— 4630	— 3400	— 5160	— 218	— 1430	— 218	— 1100	— 167	— 3040	— 3040	— 2600	— 1460	— 1460
Existing and Diverted Comfort	0	0	+ 7850	0	+ 5850	+ 4000	0	0	0	0	0	0	0	0	+ 2780	+ 2780
TOTAL	—34621	—35329	—25368	—14260	— 6960	—30217	—19364	—34870	—19931	—10479	— 5379	—35365	—36989	—31434	— 7825	— 8542

TABLE 6.3

Sensitivity summary BR 1

		COMMON ASSUMPTIONS	BEST		WORST	
		SPECIFIC ASSUMPTIONS	BEST	WORST	BEST	WORST
ASSUMPTIONS		BR 1	BR 1(A)	BR 1(B)	BR 1(C)	BR 1(D)
Traffic Estimate		High	High	High	Low	Low
Value of Time		HLSG	High	High	Low	Low
Coach Journey Time		HLSG	HLSG	HLSG	Low	Low
Benefit for Optional Check-in		0	High	0	High	0
Disbenefit for no Check-in		0	0	0	0	0
Disbenefit for Link Comfort		0	0	0	0	0
Variation in Trip Time Estimate		0	0	0	0	0
Level of Road Congestion		HLSG	HLSG	HLSG	HLSG	HLSG
Road Costs for In-Town Terminal Access		HLSG	HLSG	HLSG	HLSG	HLSG
Direct Costs Link and Terminals		HLSG	HLSG	High	HLSG	High
In-Town Modal Split Favourable to BR		HLSG	Yes	HLSG	Yes	HLSG
Sum of Discounted Annual Cost Differences	Workers	0	0	0	0	0
	Air Passengers	—19364	—34870	—19931	—10479	— 5379
	Congestion	— 926	— 1058	— 926	— 1058	— 926
	Direct	— 4973	— 4973	— 4973	— 1242	— 1242
SUB TOTAL		—25263	—40901	—25830	—12779	— 7547
Discounted Capital Cost Differences	Roads	+ 30	+ 30	+ 30	+ 30	+ 30
	Direct	+22535	+22535	+23890	+22535	+23890
SUB TOTAL		+22565	+22565	+23920	+22565	+23920
TOTAL		— 2698	—18336	— 1910	+ 9786	+16373
Ratio of Discounted Annual Cost Savings to Capital Costs		1.12:1	1.80:1	1.08:1	0.57:1	0.32:1

HLSG = the value used in this study

Table 6.4

Sensitivity summary BR 2

		COMMON ASSUMPTIONS	BEST		WORST	
		SPECIFIC ASSUMPTIONS	BEST	WORST	BEST	WORST
ASSUMPTIONS		BR 2	BR 2(A)	BR 2(B)	BR 2(C)	BR 2(D)
Traffic Estimate		High	High	High	Low	Low
Value of Time		HLSG	High	High	Low	Low
Coach Journey Time		HLSG	HLSG	HLSG	Low	Low
Benefit for Optional Check-in		0	High	0	High	0
Disbenefit for no Check-in		0	0	0	0	0
Disbenefit for Link Comfort		0	0	0	0	0
Variation in Trip Time Estimate		0	0	0	0	0
Level of Road Congestion		HLSG	HLSG	HLSG	HLSG	HLSG
Road Costs for In-Town Terminal Access		HLSG	HLSG	HLSG	HLSG	HLSG
Direct Costs Link and Terminals		HLSG	HLSG	High	HLSG	High
In-Town Modal Split Favourable to BR		HLSG	Yes	HLSG	Yes	HLSG
Sum of Discounted Annual Cost Differences	Workers	0	0	0	0	0
	Air Passengers	—19364	—34870	—19931	—10479	— 5379
	Congestion	— 570	— 642	— 570	— 642	— 570
	Direct	+ 4246	+ 4246	+ 4246	+ 6107	+ 6107
SUB TOTAL		—15688	—31266	—16255	— 5014	+ 158
Discounted Capital Cost Differences	Roads	— 96	— 96	— 96	— 96	— 96
	Direct	+21772	+21772	+22272	+21772	+22272
SUB TOTAL		+21676	+21676	+22176	+21676	+22176
TOTAL		+ 5988	— 9590	+ 6173	+16662	+22586
Ratio of Discounted Annual Cost Savings to Capital Costs		.73:1	1.44:1	.73:1	.30:1	0:1

HLSG = the value used in this study

TABLE 6.5

Sensitivity summary BR 3

		COMMON ASSUMPTIONS	BEST		WORST	
		SPECIFIC ASSUMPTIONS	BEST	WORST	BEST	WORST
ASSUMPTIONS		BR 3	BR 3(A)	BR 3(B)	BR 3(C)	BR 3(D)
Traffic Estimate		High	High	High	Low	Low
Value of Time		HLSG	High	High	Low	Low
Coach Journey Time		HLSG	HLSG	HLSG	Low	Low
Benefit for Optional Check-in		0	0	0	0	0
Disbenefit for no Check-in		0	0	0	2/-	2/-
Disbenefit for Link Comfort		0	0	0	0	0
Variation in Trip Time Estimate		0	0	+5 min	+5 min	+5 min
Level of Road Congestion		HLSG	HLSG	HLSG	Favours BR	Favours LT
Road Costs for In-Town Terminal Access		HLSG	HLSG	HLSG	Favours BR	Favours LT
Direct Costs Link and Terminals		HLSG	HLSG	High	HLSG	High
In-Town Modal Split Favourable to BR		HLSG	Yes	HLSG	Yes	HLSG
Sum of Discounted Annual Cost Differences	Workers	0	0	0	0	0
	Air Passengers	—35365	—36989	—31434	— 8542	— 7825
	Congestion	— 880	— 880	— 880	— 1280	— 1760
	Direct	— 3733	— 3733	— 3733	— 1796	— 1796
SUB TOTAL		—39978	—41602	—36047	—11618	—11381
Discounted Capital Cost Differences	Roads	— 96	— 96	— 96	— 92	+ 256
	Direct	+16009	+16029	+16509	+16009	+16509
SUB TOTAL		+15913	+15913	+16413	+15917	+16775
TOTAL		—24065	—25689	—19634	+ 4299	+ 5394
Ratio of Discounted Annual Cost Savings to Capital Costs		2.50:1	2.61:1	2.20:1	.74:1	.68:1

HLSG = the value used in this study

TABLE 6.6

Sensitivity summary LT

	Comparison	LT versus BR 1 and BR 2				LT versus BR 3			
	Common Assumptions	Best		Worst		Best		Worst	
	Specific Assumptions	Best	Worst	Best	Worst	Worst	Best	Worst	Best
ASSUMPTIONS	LT	LT(A)	LT(B)	LT(C)	LT(D)	LT(E)	LT(F)	LT(G)	LT(H)
Trafic Estimate	High	High	High	Low	Low	High	High	Low	Low
Value of Time	HLSG	High	High	Low	Low	High	High	Low	Low
Coach Journey Time	HLSG	HLSG	HLSG	Low	Low	HLSG	HLSG	Low	Low
Benefit for Optional Check-in	0	0	0	0	0	0	0	0	0
Disbenefit for no Check-in	0	0	2/–	0	2/–	0	0	2/–	2/–
Disbenefit for Link Comfort	0	0	1/–	0	1/–	1/–	0	1/–	1/–
Variation in Trip Time Estimate	0	0	0	0	0	0	0	0	0
Level of Road Congestion	HLSG	HLSG	HLSG	HLSG	HLSG	HLSG	HLSG	HLSG	Favours LT
Road Costs for In-Town Terminal Access	HLSG	HLSG	HLSG	HLSG	HLSG	HLSG	HLSG	Favours BR	Favours LT
Direct Costs Link and Terminals	HLSG	Low	High	Low	High	High	Low	High	Low
Sum of Discounted Annual Costs									
Workers	— 574	— 574	— 574	— 512	— 512	— 574	— 574	— 512	— 512
Air Passengers	—34621	—35329	—25368	—14260	— 6960	—30217	—35329	— 6960	— 6960
Congestion	— 1650	— 1650	— 1650	— 1650	— 1650	— 1650	— 1650	— 1650	— 3300
Direct	— 6552	— 6552	— 6457	— 4538	— 4538	— 6457	— 6552	— 4538	— 4538
SUB TOTAL	—43397	—44105	—34049	—20960	—13660	—38898	—44105	—13660	—15310
Discounted Capital Cost Differences — Roads	— 649	— 649	— 649	— 649	— 649	— 649	— 649	— 464	— 1153
Direct	+12535	+12135	+13197	+12135	+13197	+13197	+12135	+13197	+12135
SUB TOTAL	+11886	+11486	+12548	+11486	+12548	+12548	+11486	+12733	+10982
TOTAL	—31511	—32619	—21501	— 9474	— 1112	—26350	—32619	— 927	— 4328
Ratio of Discounted Annual Costs Savings to Capital Costs	3.65:1	3.83:1	2.72:1	1.82:1	1.09:1	3.10:1	3.83:1	1.07:1	1.40:1

HLSG = the value used in this study

TABLE 6.7

Ratio of benefits to costs under the various combinations of general and specific assumptions for Schemes BR 1, BR 2 and LT

Combination of general assumptions for all three links	Specific assumptions for each link	BR 1		BR 2		LT	
		Sensitivity Code	Benefit/ Cost Ratio	Sensitivity Code	Benefit/ Cost Ratio	Sensitivity Code	Benefit/ Cost Ratio
Best	Best	(A)	1·8	(A)	1·4	(A)	3·8
Best	Worst	(B)	1·1	(B)	0·7	(B)	2·7
Worst	Best	(C)	0.6	(C)	0·3	(C)	1·8
Worst	Worst	(D)	0·3	(D)	0·1	(D)	1·1

TABLE 6.8

Ratio of benefits to costs under the various combinations of general and specific assumptions for Schemes BR 3 and LT

Combination of general assumptions for both links	Specific assumptions for each link	BR 3		LT	
		Sensitivity Code	Benefit/ Cost Ratio	Sensitivity Code	Benefit/ Cost Ratio
Best	Best	(A)	2·6	(F)	3·8
Best	Worst	(B)	2·2	(E)	3·1
Worst	Best	(C)	0.8	(H)	1·4
Worst	Worst	(D)	0·7	(G)	1·1

6.2.2. Tables 6.7 and 6.8 show that the ranking of the schemes does not change on any reasonable combination of assumptions. On the best general assumptions, the worst benefit-cost ratio for LT (2.7) is better than the best for BR 1 (1.8) or BR 2 (1.4). Under the worst general assumptions, the situation is the same and even on the worst possible combination of general and specific assumptions the benefits of the LT scheme are greater than its costs.

6.2.3. Similarly, Table 6.8 comparing LT and BR 3 shows that again the worst specific assumptions for the LT scheme still produce better results than the best cases for BR 3, under either set of common assumptions.

6.2.4. The financial results have been subjected to sensitivity analysis in an identical manner. The results (using the same coding as for the cost-benefit analysis) are shown in Tables 6.9 and 6.10. The conclusions are similar under both the best and the worst general assumptions. In each case the worst case for LT is better than the best for BR, with the single exception of the BR 1 scheme under the best general assumptions. In that case, the best BR return (10.7%) is better than the worst LT return (9.7%).

TABLE 6.9

Financial rates of return for a 25 year period under the various combinations of general and specific assumption for schemes BR 1, BR 2 and LT.

Combinations of general assumption for both schemes	Specific assumptions for each scheme	BR 1	BR 2	LT
Best	Best	(A) 10·7%	(A) 2·9%	(A) 11·9%
Best	Worst	(B) 9·9%	(B) 1·6%	(B) 9·7%
Worst	Best	(C) 6·5%	(C) 0%	(C) 8·7%
Worst	Worst	(D) 6·0%	(D) 0%	(D) 6·7%

TABLE 6.10

Financial rates of return for a 25 year period under the various combinations of general and specific assumptions for schemes BR 3, and LT.

Combination of general assumptions for both schemes	Specific assumptions for each scheme	BR 3	LT
Best	Best	(A) 6·5%	(F) 11·9%
Best	Worst	(B) 6·2%	(E) 10·0%
Worst	Best	(C) 1·6%	(H) 7·4%
Worst	Worst	(D) 1·4%	(G) 6·7%

7. UNQUANTIFIED FACTORS

7.1. *The Major Unquantified Factors*

7.1.1. We have tried to include in the costing exercise all the increases and reductions properly attributable to each solution. But there remains a number of features which cannot sensibly be quantified in the present state of knowledge and others which, by their nature, probably will never be quantifiable. The best that can be done is to identify and examine these factors and to consider whether the net difference between the solutions on these grounds leans in the same direction as the quantified elements or not. And if it suggests a different order of preference, are the unquantified factors so important, when weighed against the cost differences set out in Table 5.1 as to invalidate the conclusions?

7.1.2. Table 7.1 lists what we consider the six most significant factors which have not been taken into account in our cost-benefit and financial analysis, and summarises our assessment of each of them as they affect each scheme. Some have already been mentioned in Chapter 6, where we tested the effect of placing arbitrary money values on some of them. Those sensitivity tests are no more than a guide to the importance of these factors, which remain "unquantifiable" in the present state of knowledge. It is however, important to avoid any inadvertant double counting of those items which are included both here and in Chapter 6.

7.2. *Factors affecting the Modal Split* (*the internal effects*)

7.2.1. These affect not only the order of preference on a cost-benefit basis but also the financial out-turn. Their effect can be gauged by sensitivity tests which assume different modal splits. The model used for modal split estimates in the study takes into account cost and speed as factors affecting modal choice for all the solutions. However it takes account of other factors which probably play a a part, eg comfort and convenience, reliability, and baggage handling facilities only in the choice between coaches and private travel. It cannot account for these factors in the choice between private travel and the rail links or between coaches and the rail links, because at the time the basic data was collected the coaches were the only public mode available. There is no behavioural evidence on which to base estimates of choice between two public modes. It is therefore necessary to consider subjectively how far these other factors might influence choice. In Chapter 6 we have shown the effects of setting a high monetary value on them, re-working the modal split, and re-calculating the benefits.

7.3. *Factors not affecting the Modal Split* (*the external effects*)

7.3.1. An obvious example would be the environmental effects of any solution. There are several aspects, from the disturbance caused during construction to the impression the finished link makes on foreign visitors and thus on the volume of tourism. Unquantifiable characteristics can also vary in degree; some, like the effect on foreign visitors, must remain purely subjective. But others are in

TABLE 7.1

Factors affecting choice of link which have not been included in the cost-benefit conditions

Factor	BR 1	BR 2	BR 3	LT
Choice of 2 public modes	No	Yes	Yes	Yes
Option of check-in in central London for rail-link passengers	Yes	Yes	No	No
Comfort	Good	Good	Good	Fair/Good
Baggage handling	Very Good*	Very Good*	Fair/Good	Fair
Reliability	Good	Good	Good	Very Good
Town Planning	Acceptable	Acceptable	Acceptable	Acceptable

*Assuming a reliable system can be developed

principle quantifiable though the data may not be available or present techniques not up to the calculations involved. Perhaps the most important "unquantifiable" of all is the advantage which the "plus coach" solutions have over the "single public mode" solutions.

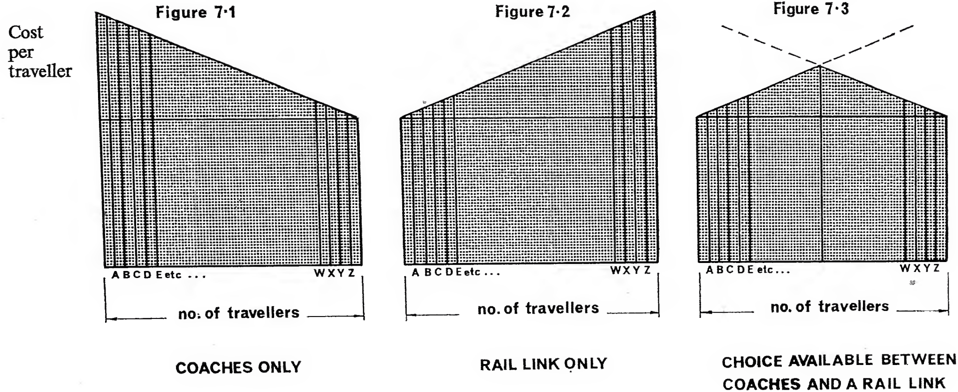
7.3.2. In the absence of any behavioural evidence in a two public mode situation the modal split model we have used assumes that when costs by each of two public transport modes are perceived as equal, 50% will go by each. The total number using public transport is assumed to be no greater than with only one public mode. This is almost certainly to undervalue the advantages of choice. Put more simply the schemes which retain coach services are less open to criticism on general grounds like comfort and reliability simply because they offer choice. The man who puts a very high value on comfort and would therefore suffer disproportionately from having to carry his own luggage, or having to stand for a while on the LT link, can always go by coach. If reliability is the important factor and the possibility of delay on the road is unacceptable then he can use the rail link. To add a rail link to the existing options rather than doing nothing, or substituting a rail link for the coaches, has the merit of widening the range of choice. The techniques used in the study do not quantify this very clear advantage, which must therefore be borne in mind in making any direct comparison between solutions offering a single public transport mode and those offering two. We tried to demonstrate how serious this might be.

7.3.3. We first assumed a uniform distribution among users of public transport between the one extreme, valueing the unquantifiable advantages of a fixed link very highly, and the other where the unquantifiable advantages of coach travel are valued very highly. There must obviously be some form of distribution between these extremes, which can be notionally represented by the diversion curves shown in the graphs on Figures 7.1 to 7.3. Thus in the "coaches only" situation there is a total cost area which can be shown as in Figure 7.1; and in a "rail link only" situation another as in Figure 7.2. Figure 7.3 then shows how, when both a rail link *and* coaches are available, the total cost will fall through different people choosing the alternative they perceive as having the greater value.

7.3.4. The number of travellers by a particular mode is obviously related to the cost of travel by that mode, so that the above effect can also be described in terms of demand. Cost is C1, and the number of travellers Q1. If the coach system is replaced by a rail system with a new cost C2 and the new quantity of travellers Q2, the savings in user costs could be calculated. When coaches are re-introduced as a competing system, Figure 7.5 would relate to the coach system with Figure 7.4. referring to rail. Those who prefer coach to rail would switch over to the coach system. And at the original cost C1, the number going by coach will be Q3. This movement over to coach, would cause a reduction in the demand for rail at the rail cost C2, and the numbers remaining on the rail system would be Q4. The demand curves are constructed in line with the assumption that if the cost by each system were identical the numbers going by each would be the same.

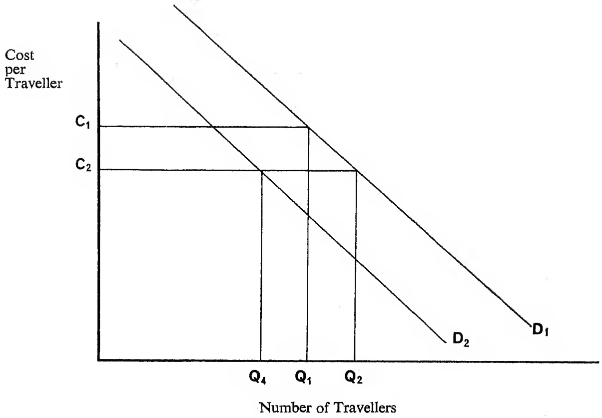
7.3.5. The costs of the people who stay on the rail system are the same as if the coaches had not been re-introduced. Those who move back to the coaches must have lower costs, otherwise they would not move. The last person to move

Distribution of Travellers' Perceived Costs per Mode



Demand for Travel

Figure 7·4



Demand for Travel

Figure 7·5

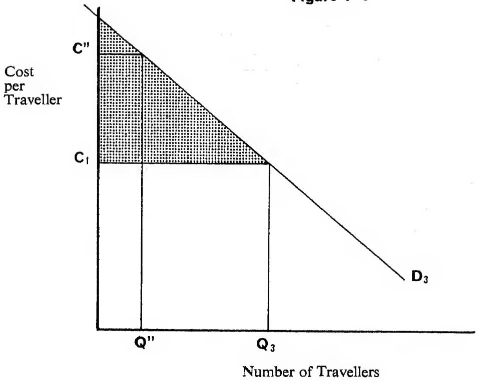


TABLE 7.2

Baggage Distribution

	Pieces of Checked Baggage				Unchecked Baggage			
	None	One	Two	Over Two	None	One	Two	Over Two
Within Europe								
Tourist	15%	64%	17%	4%	46%	50%	3%	1%
First	16%	57%	22%	5%	38%	55%	6%	1%
N. America/Europe								
Tourist	1·6%	60%	34%	4·4%	38%	60%	2%	—
First	—	50%	44%	6%	27%	67%	6%	—
Europe/N. America								
Tourist	0.9%	61%	32%	5·1%	42%	54%	4%	—
First	0·9%	59%	30%	10·1%	28%	61%	11%	—
Europe/Far East								
Tourist	2%	71%	25%	2%	10%	80%	10%	—
First	—	44%	40%	16%	16%	73%	6%	5%
Far East/Europe								
Tourist	—	51%	44%	15%	44%	52%	4%	—
First	—	50%	46%	4%	17%	66%	9%	8%
World Wide								
Tourist	8·5%	64%	23%	4·5%	44%	51%	3·5%	1·5%
First	6%	53%	31%	10%	33%	59%	7.5%	0·5%

TABLE 7.3

Baggage Size (by sum of three dimensions)

Checked Baggage **Less than 45″** 3%	**45″** 40%	**55″** 40%	**62″** 12%	**Over 62″** 5%
Unchecked **25″** 50%	**35″** 42%	**45″** 8%		

The following data was drawn from a baggage survey conducted by BEA and covering the Summers of 1966, 1967 and 1968:

TABLE 7.4

Hand Baggage Average per passenger

	Summer '66	Summer '67	Summer '68
Pieces/passenger			
—DOMESTIC	0·91	0·87	0·90
—INTERNATIONAL	1·09	1·09	1·09
Kg/passenger			
—DOMESTIC	10·20	9·60	10·30
—INTERNATIONAL	13·40	13·00	12·80

NOTE

Basic Data

Size of sample	17,000 bags
Average piece weight of checked baggage	12·8 kgs
Average piece weight of unchecked baggage	4·3 kgs
Average number of checked pieces carried	1·3 kgs
Average number of unchecked pieces carried	0.9 kgs

TABLE 7.5

Trend of Season Ticket Journeys on the Western Piccadilly Line (Hounslow trains only)

	Annual Journeys (000's) 1961	(A) 1968	Percentage Decrease	6/7ths of Col. 3	Assumed Percentage Decreased compared with 1969: 1974 (B)	1981 (C)
	(1)	(2)	(3)	(4)	(5)	(6)
Hounslow West	699	432	38	32½	27	54
Hounslow Central	1,051	671	36	31	26	52
Hounslow East	1,547	1,029	33	28	24	48
Osterley	1,963	1,384	30	26	21	45
Boston Manor	2,189	1,561	29	25	21	44
Northfields	2,713	1,958	28	24	20	42
South Ealing	3,001	2,213	26	22	19	39
Acton Town	3,134	2,366	25	21½	18	38
Hammersmith	3,626	2,889	20	17	14	31
Barons Court	3,682	2,978	19	16	14	29
Earls Court	4,200	3,563	15	13	11	24
Gloucester Road	4,247	3,649	14	12	10	23
South Kensington	4,288	3,717	13	11	9	21
Knightsbridge	4,320	3,759	13	11	9	21
Hyde Park Corner	4,326	3,770	13	11	9	21
Green Park	4,348	3,797	13	11	9	21

Notes:

(A) Cumulative from Hounslow West.

(B) Based on the assumption that the decline in the 5 years 1969/1974 will be 5/7ths of the percentage decline experienced in the 7 year period 1961/1968.

(C) Based on the assumption that the percentage decline in the 6 years 1969/1975 and in the 6 years 1975/1981 will be 6/7ths of the percentage decline experienced in the 7 year period 1961/1968.

over presumably has a total perceived cost reduction about equal to those he had with the rail link only. So a consumer Q" with a higher than average preference for coach would have been willing to pay C". Since he in fact pays only C_1 he receives a profit of $C"-C_1$ due simply to the existence of choice. The extra benefit of the choice of coach and rail versus rail only must then be equal to the total consumer surplus shown as the shaded area in Figure 7.5.

7.3.6. The size of this benefit could in theory be calculated by progressively increasing coach cost and calculating, using the diversion curve, the numbers that would use coach at each level until everyone went by rail. This has not been done mainly because the diversion curve between the two public modes is hypothetical. It should be reasonably accurate in estimating changes close to the 1:1 ratio within which we are working in making the modal split for Heathrow. But it is likely to be very inaccurate when approaching ratios of 2:1 leading to serious over-estimates of the benefits.

7.4. *Factors specific to an LT link*

7.4.1. The 1967 TCCL report listed three major objections to the London Transport link then proposed:—

i. its inability to offer full baggage handling facilities;
ii. its inability to offer adequate seating capacity at all times; and
iii. its inability to offer a full 24 hour service.

The present LT scheme with continued coach operations is of course somewhat different. The coaches would continue as the only public transport link during the small hours so that the only relative disadvantage of the LT scheme is that during the periods when the underground is closed there is less choice for the traveller than in schemes BR 2 and BR 3. The distribution of air passengers suggests that about 2% travel during the hours the London Transport link would be shut down. LT could provide a 24 hour service, working from a station in the Kensington area for part of the night, but, given continued coach operation, they do not believe it is necessary.

7.4.2. To that extent the degree of extra choice offered is less than by the two BR plus coaches schemes and the revenue effects of the shut-down period have been taken into account in the financial assessment. It is still possible to criticise the London Transport solution as not providing adequate baggage handling facilities. It can be argued that London Transport's trains are inconvenient for passengers with heavy luggage, that boarding and alighting is difficult, and that the absence of porters would be a hardship for some people. London Transport have attempted to meet the point by arranging to provide luggage space in Piccadilly Line trains—at the cost of taking out four seats in each car. And given the continued operation of the coaches much of the strength is taken out of this line of argument. It remains true that London Transport is offering a lower level of service in this respect, which is reflected in the lower fare. This difference is, of course, less when comparing LT with BR 3 than with the two BR options with check-in facilities at Victoria. Tables 7.2 to 7.4 give details of the numbers and size of bags carried by airline passengers. Many airline passengers start their journey by tube now, and holiday-makers carrying their baggage are commonplace on the underground.

7.4.3. The remaining TCCL objection to the LT link, its inability to offer adequate seating capacity at all times, and the more general question of standards of comfort, remain.

7.4.4. The maximum "crush" hourly capacity of the proposed 15 seven car trains per hour in the commuter peak periods, assuming all seats and standing accommodation were fully occupied to the limit, would be about 17,000. Because even loading is never in practice achieved, to allow for the peak within the peak, and to achieve reasonable standards of comfort, London Transport adopt a "comfort capacity" to represent the practical one hour load which will give reasonable travelling conditions. This "comfort capacity" of the 15 seven car trains is 11,700, some two thirds of the maximum "crush" capacity and three times the seating capacity of 3,900. All these figures assume the replacement of 4 seats per car by luggage racks. A suitcase on the floor occupies the same space as a standing passenger.

7.4.5. In recent years commuter traffic on most sections of the underground system has remained fairly static. Some loss of commuters from suburban sections of the system has been offset by an increase in commuters from British Rail termini to and within the Central Area. On the western sections of the Piccadilly Line however, there has been a consistent downward trend partly because of the increasing attraction of employment to West London (not least at Heathrow Airport itself) and partly because the western section of the Piccadilly Line serves no British Railways termini and produces no compensating in-town distribution traffic. It also runs parallel to the M4.

7.4.6. On the basis of season ticket issues from 1961 onwards (see Table 7.5) this downward trend amounts to about 2% a year, most of it on the outer sections. In particular there has been a drop of 5% a year on the section from Hounslow West to South Ealing. Bearing in mind the forecast decrease in the labour force in areas served by the outer sections of the Piccadilly Line and the expected rise in employment at Heathrow Airport, it is expected that this downward trend will continue. But we have assumed that over the period 1970 to 1981 the decrease will be slightly slower. To test the sensitivity of the results to this assumption we have also estimated the loadings on the extremely pessimistic basis of no decline at all in ordinary commuter traffic. Tables 7.6 to 7.9 set out the estimated loadings in the peak hours, on both assumptions and for 1974 as well as 1981. On the assumption of a continuing downward trend in commuter traffic 1974 loads are higher than any other year.

7.4.7. The Tables show that even on the most pessimistic assumptions there would be capacity, within LT's comfort standard, to carry all the traffic estimated to use the LT link. But taking into account the "peak within the peak", that is the 15 minutes or so within the peak hour during which up to one third of the peak hour load is carried, the comfort capacity could be slightly exceeded in both years if there is no continued downward trend among present users. In that event one additional train would be needed in the peak 15 minutes for LT's "comfort capacity" to exceed our forecast demand. It is operationally possible to run up to six additional trains in the peak hour. Each would cost £215,000 and the annual running costs would be £16,000.

7.4.8. Airline passengers from Heathrow to London would always be assured of a seat. Travelling to the Airport some would have to stand on boarding, but because other passengers would be alighting at each station they would usually find a vacant seat after a few stops. Airport passengers travelling during the peak hour are about 8% of the total so only about 2% of airport passengers (ie those travelling *to* Heathrow, with the commuter flow, in the evening peak) would need to stand, and then for only part of their journey.

7.4.9. The time other passengers spend standing in the peak periods would increase if the link opened in 1974, but would then fall again each year as commuter traffic declines. By 1981 there would be less standing time than there is now.

7.4.10. As a sensitivity test we considered the effect of assuming no downward trend in commuter traffic, in which case the amount of standing necessary in the peaks would increase year by year to 1981. To bring the total standing time in the peak periods down to 1969 levels 6 additional trains would then be needed in the peak hour. That would be operationally possible at a cost, in 1970 present value terms, of less than £2m (see also paragraph 6.1.9.)

7.4.11. On the other hand the LT scheme also has advantages which have not been included in the calculations. It has a slight advantage in reliability, since the service is less likely to be affected by extreme weather conditions or by interaction with other services. The LT link alone offers a comprehensive service to the airport workers and because it has two stations within the Airport could also be useful for internal journeys there. In the slightly longer term the LT link, by extending the potential labour catchment area of the Airport, would benefit both employers at the Airport and the people living in areas where travel to work at Heathrow becomes a possibility. Both would have their area of choice widened. And increasing the chances of successfully matching man and job should lead to more effective use of manpower.

7.4.12. So far as we could discover none of the schemes would be likely to raise major objections from the local planning authority concerned. Both links offer some potential for associated development subject, of course, to planning permission. Because of the number of stations served by the Piccadilly Line, the London Transport Link may offer greater though more dispersed scope in this respect. It does not seem however, that any difference will be significant enough to influence choice between a British Rail or a London Transport Link.

7.5. *Factors specific to a BR Link*

7.5.1. The withdrawal of the airline coach services is an essential feature of scheme BR 1. This limitation on choice is a serious dis-benefit of the scheme which is not reflected in the cost-benefit calculations (see 7.3. above). It is this creation of a virtual monopoly on public transport to the Airport which is largely responsible for the relatively good financial forecast for scheme BR 1. Since those passengers who would prefer a lower level of service if it were cheaper have no alternative means of public transport they are obliged—unless they switch to private transport—to pay for a service they do not want. In effect they would then be subsidising other users of the link. If we assume that, in general, lower income groups will prefer the cheaper means of travel the inference is that scheme BR 1 involves the less well off subsidising the better off. Put more simply,

TABLE 7.6

Piccadilly Hounslow line loadings 1969 and 1974 Eastbound A.M. peak hour

Leaving Station	1969	1974 – LT ESTIMATE								1974 – BASIS AS BELOW*		
			Generated by Link									
		Pre-extension Traffic	Airline Passengers	Staff	Misc.	Hatton Cross Commuters	Total	Passengers boarding	Passengers alighting	Total	Passengers boarding	Passengers alighting
Heathrow Central	—	—	1,120	70	40	—	1,230	1,230	—	1,230	1,230	—
Hatton Cross	—	—	1,120	70	40	600	1,830	630	30	1,830	630	30
Hounslow West	1,200	880	1,120	60	40	540	2,640	820	10	2,960	1,140	10
Hounslow Central	2,000	1,480	1,110	50	40	540	3,220	600	20	3,740	800	20
Hounslow East	3,000	2,280	1,110	40	40	540	4,010	800	10	4,730	1,000	10
Osterley	3,800	3,000	1,110	40	40	480	4,670	660	—	5,470	740	—
Boston Manor	4,200	3,320	1,100	30	40	480	4,970	330	30	5,850	410	30
Northfields	4,900	3,920	1,100	30	40	470	5,560	660	70	6,540	780	90
South Ealing	5,000	4,050	1,100	30	40	440	5,660	240	140	6,610	240	170
Acton Town	5,200	4,260	1,040	20	40	370	5,730	530	460	6,670	600	540
Hammersmith	5,500	4,730	840	10	30	270	5,880	1,170	1,020	6,650	1,200	1,220
Barons Court	5,800	4,990	780	10	30	250	6,060	340	160	6,870	400	180
Earls Court	7,600	6,760	650	—	20	220	7,650	1,940	350	8,490	2,000	380
Gloucester Road	8,000	7,200	480	—	20	220	7,920	440	170	8,720	430	200
South Kensington	8,500	7,740	450	—	20	210	8,420	700	200	9,180	700	240
Knightsbridge	7,400	6,730	430	—	20	210	7,390	100	1,130	8,060	100	1,220
Hyde Park Corner	7,100	6,460	410	—	20	190	7,080	100	410	7,720	100	440
Green Park	5,100	4,640	350	—	10	190	5,190	500	2,390	5,650	500	2,570
Piccadilly Circus	4,900	3,900	320	—	10	120	4,350	900	1,740	4,750	1,000	1,900
Leicester Square	4,100	3,730	230	—	10	90	4,060	650	940	4,430	700	1,020
Covent Garden	3,900	3,550	200	—	10	90	3,850	100	310	4,200	100	330
Holborn	2,200	2,000	150	—	10	30	2,190	550	2,210	2,390	600	2,410
Russell Square	1,700	1,550	110	—	—	30	1,690	50	550	1,840	50	600

*Assuming the 1974 pre-extension traffic remains at the 1969 level.

TABLE 7.7

Piccadilly Hounslow line loadings 1969 and 1981 Eastbound A.M. peak hour

Leaving Station	1969	1981 – LT ESTIMATE								1981 – BASIS AS BELOW*		
		Pre-extension Traffic	Generated by Link				Total	Passengers Boarding	Passengers Alighting	Total	Passengers Boarding	Passengers Alighting
			Airline Passengers	Staff	Misc.	Hatton Cross Commuters						
Heathrow Central	—	—	1,630	90	40	—	1,760	1,760	—	1,760	1,760	—
Hatton Cross	—	—	1,630	90	40	600	2,360	640	40	2,360	640	40
Hounslow West	1,200	550	1,630	80	40	540	2,840	490	10	3,490	1,140	10
Hounslow Central	2,000	960	1,620	60	40	540	3,220	410	30	4,260	800	30
Hounslow East	3,000	1,590	1,620	50	40	540	3,810	600	10	5,250	1,000	10
Osterley	3,800	2,090	1,610	50	40	480	4,270	470	10	5,980	740	10
Boston Manor	4,200	2,550	1,610	40	40	480	4,520	270	20	6,370	410	20
Northfields	4,900	2,840	1,600	40	40	470	4,990	530	60	7,050	780	100
South Ealing	5,000	3,050	1,600	40	40	440	5,170	290	110	7,120	240	170
Acton Town	5,200	3,220	1,510	20	40	370	5,160	400	410	7,140	600	580
Hammersmith	5,500	3,300	1,230	10	30	270	5,340	1,140	960	7,040	1,200	1,300
Barons Court	5,800	4,120	1,130	10	30	250	5,540	380	180	7,220	400	220
Earls Court	7,600	5,780	940	10	20	220	6,970	1,800	370	8,790	2,000	430
Gloucester Road	8,000	6,160	700	—	20	220	7,100	450	320	8,940	500	350
South Kensington	8,500	6,720	650	—	20	210	7,600	600	100	9,380	600	160
Knightsbridge	7,400	5,850	630	—	20	210	6,710	100	990	8,260	100	1,220
Hyde Park Corner	7,100	5,610	600	—	20	190	6,420	100	390	7,910	100	450
Green Park	5,100	4,030	510	—	10	190	4,740	500	2,180	5,810	500	2,600
Piccadilly Circus	4,300	3,400	460	—	10	120	3,990	800	1,550	4,890	1,000	1,920
Leicester Square	4,100	3,240	330	—	10	90	3,670	600	920	4,530	700	1,060
Covent Garden	3,900	3,080	300	—	10	90	3,480	100	290	4,300	100	330
Holborn	2,200	1,740	220	—	10	30	2,000	500	1,980	2,460	600	2,440
Russell Square	1,700	1,340	150	—	—	30	1,520	50	530	1,880	50	630

*Assuming the 1981 pre-extension traffic remains at the 1969 level.

TABLE 7.8

Piccadilly Hounslow line loadings 1969 and 1974 Westbound P.M. peak hour

Leaving Station	1969	1974 – LT ESTIMATE								1974 – BASIS AS BELOW*		
			Generated by Link									
		Pre-extension Traffic	Airline Passengers	Staff	Misc.	Hatton Cross Commuters	Total	Passengers boarding	Passengers alighting	Total	Passengers boarding	Passengers alighting
Kings Cross	1,500	1,370	70	—	10	30	1,480	—	—	1,610	—	—
Russell Square	2,000	1,820	100	—	10	30	1,960	530	50	2,140	580	50
Holborn	3,400	3,090	130	—	10	90	3,320	1,910	550	3,630	2,090	600
Covent Garden	3,700	3,370	150	—	10	90	3,620	400	100	3,950	420	100
Leicester Square	4,100	3,730	210	—	20	120	4,080	1,010	550	4,450	1,100	600
Piccadilly Circus	5,300	4,820	240	—	20	190	5,270	1,840	650	5,750	2,000	700
Green Park	7,200	6,550	280	—	20	190	7,040	2,170	400	7,690	2,390	450
Hyde Park Corner	7,600	6,920	290	—	20	210	7,440	450	50	8,120	480	50
Knightsbridge	9,000	8,190	300	—	20	210	8,720	1,330	50	9,530	1,460	50
South Kensington	8,300	7,470	320	—	20	220	8,030	130	820	8,860	130	800
Gloucester Road	7,800	6,940	430	—	30	220	7,620	160	570	8,480	160	540
Earls Court	5,500	4,730	520	10	30	250	5,540	330	2,410	6,310	330	2,500
Barons Court	5,100	4,390	570	10	40	270	5,280	180	440	5,990	180	500
Hammersmith	4,700	3,850	690	20	50	370	4,980	970	1,270	5,830	1,140	1,300
Acton Town	4,500	3,650	730	30	50	440	4,900	470	550	5,750	520	600
South Ealing	4,400	3,520	740	30	50	470	4,810	150	240	5,690	180	240
Northfields	3,800	3,000	740	30	50	480	4,300	70	580	5,100	90	680
Boston Manor	3,500	2,770	740	40	50	480	4,080	20	240	4,810	20	310
Osterley	2,700	2,050	740	40	50	540	3,420	60	720	4,070	60	800
Hounslow East	1,900	1,410	750	50	50	540	2,800	20	640	3,290	20	800
Hounslow Central	1,200	880	750	60	50	540	2,280	10	530	2,600	10	700
Hounslow West	—	—	750	70	50	600	1,470	70	880	1,470	70	1,200
Hatton Cross	—	—	750	70	50	—	870	30	630	870	30	630
Heathrow Central	—	—	—	—	—	—	—	—	870	—	—	870

*Assuming the 1970 pre-extension traffic remains at the 1969 level.

TABLE 7.9

Piccadilly Hounslow line loadings 1969 and 1981 Westbound P.M. peak hour

Leaving Station	1969	1981 – LT ESTIMATE								1981 – BASIS AS BELOW*		
		Pre-extension Traffic	Generated by Link				Total	Passengers boarding	Passengers alighting	Total	Passengers boarding	Passengers alighting
			Airline Passengers	Staff	Misc.	Hatton Cross Commuters						
Kings Cross	1,500	1,190	100	—	10	30	1,330	—	—	1,640	—	—
Russell Square	2,000	1,580	150	—	10	30	1,770	490	50	2,190	600	50
Holborn	3,400	2,690	190	—	10	90	2,980	1,710	500	3,690	2,100	600
Covent Garden	3,700	2,920	220	—	10	90	3,240	360	100	4,020	430	100
Leicester Square	4,100	3,240	310	—	20	120	3,690	950	500	4,550	1,130	600
Piccadilly Circus	5,300	4,190	340	—	20	190	4,740	1,650	600	5,850	2,000	700
Green Park	7,200	5,690	400	—	20	190	6,300	1,960	400	7,810	2,410	450
Hyde Park Corner	7,600	6,000	420	—	20	210	6,650	400	50	8,250	490	50
Knightsbridge	9,000	7,110	430	—	20	210	7,770	1,170	50	9,660	1,460	50
South Kensington	8,300	6,390	470	—	20	220	7,100	150	820	9,010	200	850
Gloucester Road	7,800	5,930	630	10	30	220	6,820	190	470	8,690	190	510
Earls Court	5,500	3,910	760	10	30	250	4,960	360	2,220	6,550	360	2,500
Barons Court	5,100	3,520	820	10	40	270	4,660	170	470	6,240	190	500
Hammersmith	4,700	2,910	1,010	20	50	370	4,360	860	1,160	6,150	1,210	1,300
Acton Town	4,500	2,750	1,070	40	50	440	4,350	370	380	6,100	550	600
South Ealing	4,400	2,550	1.070	40	50	470	4,180	110	280	6,030	210	280
Northfields	3,800	2,130	1,070	40	50	480	3,770	50	460	5,440	90	680
Boston Manor	3,500	1,930	1,080	50	50	480	3,590	30	210	5,160	30	310
Osterley	2,700	1,400	1,080	50	50	540	3,120	50	520	4,420	50	790
Hounslow East	1,900	910	1,080	60	50	540	2,640	10	490	3,630	10	800
Hounslow Central	1,200	550	1,090	80	50	540	2,310	30	360	2,960	30	700
Hounslow West	—	—	1,090	90	50	600	1,830	60	550	1,830	60	1,190
Hatton Cross	—	—	1,090	90	50	—	1,190	40	680	1,190	40	680
Heathrow Central	—	—	—	—	—	—	—	—	1,190	—	—	1,190

*Assuming the 1981 pre-extension traffic remains at the 1969 level.

the present range of choice in means of travel to the Airport runs from coaches through taxis and cars to a chauffeur driven limousine. To substitute a BR link for the coaches (or indeed to add one) does not widen the range of choice, and (in the case of BR 1) may narrow it. On the other hand the LT link, being cheaper, significantly widens the area of choice—in economic terms it increases consumer surplus.

7.5.2. Against that must be set the advantage that in schemes BR 1 and BR 2 rail passengers would have the option of checking-in at Victoria, or of saving time by going straight to the Airport and checking-in there. The choice would not be advertised because the airlines believe that to do so would cause confusion. So not everyone would realise that the choice was available. But some travellers would find out from their air tickets, or by experience.

7.5.3. All three BR schemes have some advantage over the LT one on the grounds of comfort and baggage handling. There are clearly advantages of convenience for some people in handing over their baggage in London. Without this facility the advantages of travel by British Rail are less significant though the attraction of the non-stop journey remains. And BR 3 offers overhead luggage racks so that baggage can be kept close to hand, as opposed to the LT luggage racks by the main doors of their trains. There would also be porters available at Victoria. The BR schemes, which are all exclusive to Airport passengers, have enough capacity to offer every passenger a seat at all times. For most of the day a train would be waiting at the platform so that passengers could board without even having to stand on the platform until a train pulled in.

7.5.4. All three BR schemes would be more reliable than the coaches. But because they are more likely to be affected by extreme weather conditions or by interaction with other services they would perhaps not offer quite so high a standard as the LT link. There is the particular advantage of in-town check-in, in schemes BR 1 and BR 2, which affords some protection against delays in that the airlines will generally hold up a flight for a delayed passenger who has checked in. How long they would hold a flight, and whether this practice can continue as average aircraft sizes and loadings increase is uncertain.

7.5.5. The origins of the BR proposal are inextricably linked with the redevelopment of Victoria and the provision there of a major new transportation centre, incorporating terminal facilities for Heathrow passengers. Since then the assumption that town check-in facilities were an unmixed blessing and that their capacity would grow with the growth in air travel has been widely questioned, not least by the airlines. But a BR Heathrow link is not a necessary condition of Victoria redevelopment. That can be regarded as a quite separate issue.

7.5.6. There could be advantages in providing a rail interchange for passengers travelling between Heathrow and Gatwick. It is proposed that the train services could run into adjacent platforms for maximum convenience. But we were advised that it would not be sensible to plan air schedules on the basis of large scale surface traffic between the two Airports. And there is no reason to suppose that an indirect rail connection would be any improvement on the present direct coach services.

7.5.7. More generally the BR link would have a built-in capacity for improving the quality of service should the demand for higher levels of, say, comfort grow in future years.

8. THE SCHEMES COMPARED

8.1.1. The Group concludes that scheme BR 1 should be excluded from further consideration. It is most unlikely that the airlines would be prepared to withdraw their coaches; the cost-benefit ratio of the scheme would be poor; and its financial viability, even on the highest traffic estimates, is doubtful. Its specific unquantified advantage relies heavily on the development of a sophisticated baggage handling system. This advantage must be set against the restriction of choice through the withdrawal of the coaches.

8.1.2. The BR 2 scheme offers very good standards of comfort and convenience but ranks lowest of all on both cost-benefit and financial grounds. In cost-benefit terms, the advantages of being able to check-in at Victoria, assuming a reliable baggage handling system can be developed, would have to be valued at some £30m to £38m (depending on the decision rule used) to bring it to parity with the BR 3 proposal (in revenue terms the gap is about £10m). We do not believe that the benefits of check-in and baggage handling at Victoria could reasonably be valued so highly.

8.1.3. We therefore see the real choice to be between the BR 3 and LT schemes. The BR scheme offers its passengers a shorter journey time in transit, a guaranteed seat and rather better baggage facilities. It provides a direct link between the Airport and a single point in Central London. Those factors have to be set against London Transport's cheaper fare, slight advantage in reliability and its much better showing both in the cost-benefit analysis and in the financial assessment. It provides, as distinct from British Rail, dispersed access over Central London, and an added facility for workers within the airport complex.

8.2. *Conclusions*

8.2.1. We have tried to quantify costs and benefits wherever it could sensibly be done. On that basis the best rail link is clearly the Piccadilly Line extension. We have tested the importance of factors we could not quantify, like comfort, baggage handling and reliability, by putting large monetary values on them and testing the effects of this on our assessment of each scheme. We have also tested the effects of adopting different assumptions, forecasts and values for the many variables in the calculations. Having made these tests we do not believe that there is a credible set of assumptions which would make any of the other schemes preferable to the Piccadilly Line extension within the framework of our cost-benefit analysis and financial assessment.

8.2.2. We conclude that there are considerable benefits to be gained by supplementing the present coach services between Central London and Heathrow by a rail link. If a rail link is built than it should be an extension of London Transport's Piccadilly Line from Hounslow West to Heathrow. There are always competing claims on resources and we could not attempt to compare a Heathrow Link with them. But, in the light of all the factors we could take into account, we believe that the Piccadilly Line extension would be a worthwhile investment.

Printed in England for Her Majesty's Stationery Office
by Eden Fisher & Co. Ltd., London.

Dd 501080 K24 7/20.

MINISTRY OF TRANSPORT

Report of a study of

Rail Links with Heathrow Airport

Part II

LONDON
HER MAJESTY'S STATIONERY OFFICE
1970

SBN 11 550181 9

CONTENTS

REPORT OF THE HEATHROW LINK STEERING GROUP

PART II DETAILS OF THE STUDY